PEARL

The Journal of HEREDITY

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Hairless Calves

The "Emergence" Theory

Marriage-Selection for Stature

Bolivian Sex-Ratios

VOLUME 26 SEPTEMBER, 1935 NUMBER 9

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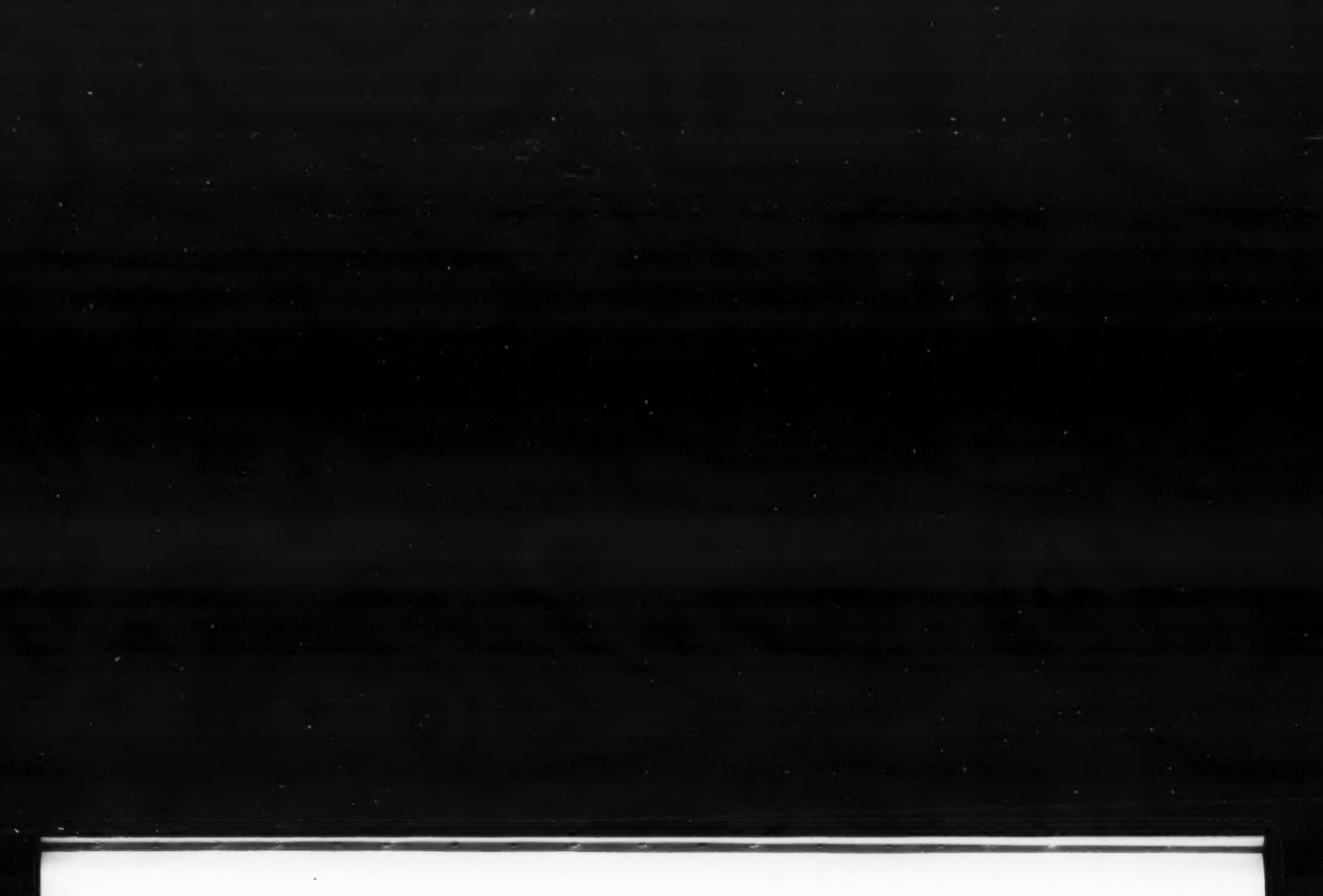

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Photograph by Dr. G. H. Shull

WHERE GENETICS BEGAN

Frontispiece

Garden in the Augustinian Monastery at Brunn, in what is now Czechoslovakia, in which Gregor Mendel carried on his historic experiments with peas. Here modern genetics may be said to have had its beginning.

MENDEL AS A MICROSCOPIST

A New Chapter in the Life of Gregor Mendel

P. F. MILOVIDOV

Charles University, Prague, Czechoslovakia

Ja, dessen Lorbeer welket nie

THE line quoted above is from a short poem written by Gregor Mendel as a young student. The thought, which might be translated "Yes, their laurels shall never wither," has rather interesting connotations when we consider Mendel's own life. Even though the recognition of their contemporaries has taken rather a negative direction, as in the case of Galileo, it may safely be said that very few of those who have made really great contributions to human thought have remained wholly unrecognized, either for purposes of praise or persecution, during their lives. It was the curious fate of Gregor Mendel to make a fundamental discovery of vast importance and to have his contribution entirely ignored. When the Abbot of the Augustinian monastery at Brno died on January 6, 1884, the world placed no laurel wreaths on his grave. Not until sixteen years later did biologists begin to take cognizance of certain obscure writings and experiments Mendel had published twenty years before his death. Now, after the lapse of half a century, we recognize that this man, whose scientific eminence during his life was almost nil, is destined to wear a wreath of appreciation through the centuries to come, as one of the great benefactors of mankind.

As the years have passed we have been able to get a clearer picture of the man than could be had at the time he became a world figure shortly after 1900. Dr. Hugo Iltis has performed a very important service in bringing together and making available much valuable information regarding Mendel's life in his biography of the discoverer of unitary heredity. It is an interesting sidelight on the retiring nature of the man that some of his activities seem to have escaped the notice of those who have made a careful study of his life. Mendel's place in science is so well fixed that additional light on his personality and scientific activities is of great interest, not only to specialists in the science founded by him, but also to a somewhat wider audience.

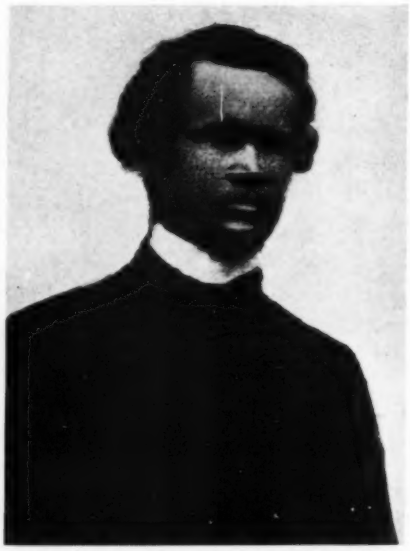
It has come to be recognized that Mendel did not hit upon the laws of heredity which bear his name in any casual manner. He is known now to have been a naturalist with a wide horizon, which happily combined the critical intellect of the scientific thinker with a talent for practical experimentation. He evidently had a passion for the study of natural phenomena. This is exemplified in the wide variety of activities which were included in his experimental researches. He compiled a great mass of accurate meteorological observations. He studied the sun spots and continued his observations of them over a considerable period. He took part in the work of an agricultural society. He was a zealous apiarist. He was a practical gardener and perhaps this fact had a bearing on his making the detailed observations based on carefully planned experiments which enabled him to enunciate the laws of heredity which today bear his name. In addition to his activities of a scientific nature he took an active part in the affairs of the religious order of which he was a member and left considerable traces in the life of the monastery of which he was the spiritual guide during his later years.

Recently the author has succeeded in obtaining evidence which proves

that in addition to all these other activities Gregor Mendel devoted himself to microscopic observation and prepared with his own hands many microscopic preparations of the most diverse objects of living and non-living matter. At least two references to the fact that Mendel owned a microscope are to be found in the literature. It is even recorded by Iltis that he overstrained his eyes by his intensive microscopical observations in his studies with Hieracium, but as far as we are aware no details regarding his microscopical researches have ever been published. The purpose of this article is to acquaint those who have an interest in Mendel's life with this new factor in the history of the great naturalist.

We are indebted to Father Anselm Matousek, procurator of the Augustinian Monastery of St. Thomas in Staré Brno for the preservation of Mendel's microscopic preparations found among his belongings. These will soon be one of the most interesting objects in the monastery museum. Our heartiest thanks are due to those in charge of the monastery of St. Thomas at Brno and especially to Father Matousek for his kindness and cooperation which have made our researches possible and for supplying us with the photographs here published for the first time. I am very grateful to Professor B. Nemec for the opportunity to photograph Mendel's letter which is reproduced here.*

May this short article concerning a hitherto almost unknown chapter in the life and scientific activity of Gregor Mendel be a modest flower on his grave!



EARLY PORTRAIT OF MENDEL

Figure 1

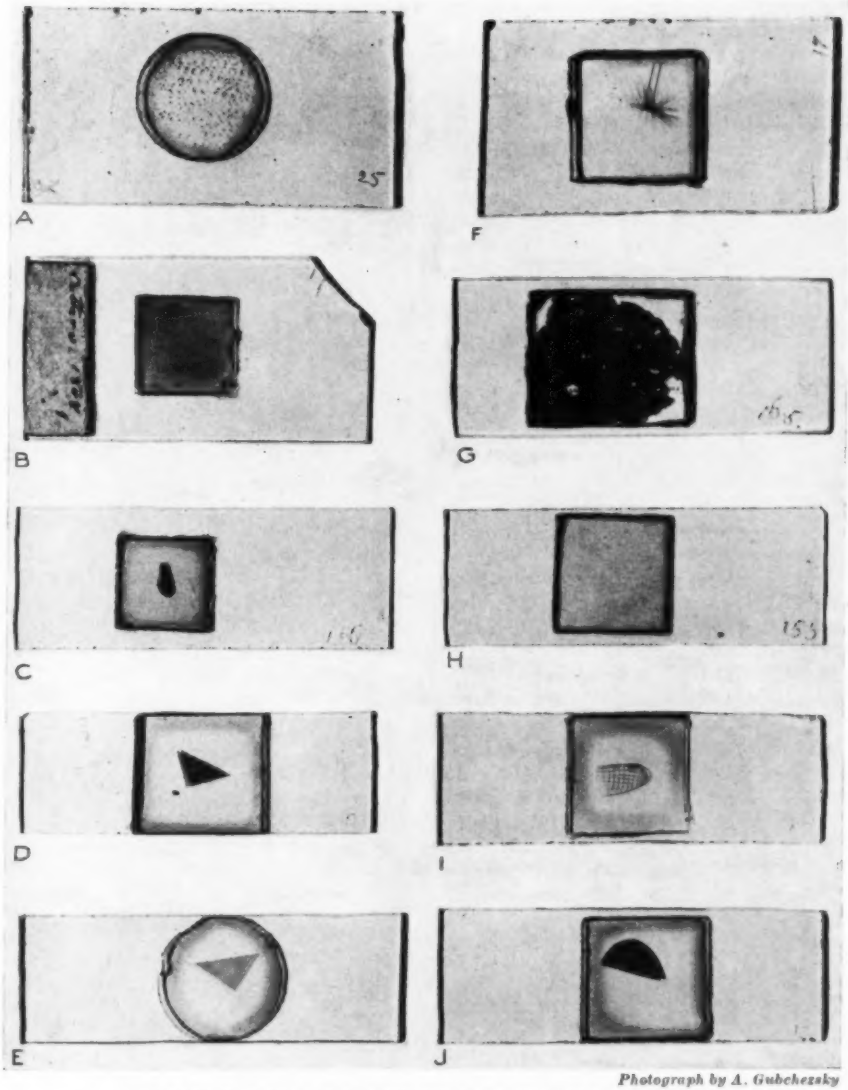
Photograph of Gregor Mendel as a young priest probably made about 1847. This hitherto unpublished photograph has been made available to the author through the kindness of Father Anselm Matousek.

Mendel's Microscopic Preparations

The appearance of Mendel's preparations is extremely original; for the most part they are preparations which he made himself, even the slides and coverslips having been evidently prepared on the spot.

The Slides. The glass slides on which the objects are mounted are mostly narrow pieces of a simple, hand cut window-glass, thick and greenish, more rarely, fine and broad. Their length at present varies from 53 to 60 mm. Since the greater part of the slides were afterwards reduced in length 2 to 3 mm., their original length must be roughly calculated as 55 to 62 mm. The thickness of the slides varies between 1 and 2 mm., in some cases it is 2.5 mm. and more, and sometimes less than 1 mm. Often one finds small air bubbles in the glass, also pieces of smoky glass

*A report on the material discussed in this article was made by the author at a special meeting of the Russian Association of Scientific Research in Prague on October 17, 1934. An exhibition of Mendel's preparations was held from October 31 to November ber 8, 1934, in the Plant Physiological Institution of the Charles University by the author.



Photograph by A. Gubchezsky

SLIDES FROM GREGOR MENDEL'S COLLECTION

Figure 2

In addition to discovering atomic heredity Mendel carried on many other scientific activities, microscopical research being one in which he was interested for many years. Among his effects has been found a collection of 169 microscopic slides, of which the ten slides shown above are a representative sample. The slides shown here contain specimens of the following objects (the slide number in the Mendel collection is shown in parenthesis in each case): *A*—sporangia and spores of fern (25); *B*—stipules of silicious sponges (no number); *C*—a moss (166); *D*—secondary xylem of dicotyledonous plant (67); *E*—same of conifer (114); *F*—pappus of a Composite (71); *G*—polished section of an eruptive rock (168); *H*—unidentified crystals (155); *I*—part of wing of a dragonfly (135); *J*—part of a wing of another species of dragonfly (137).

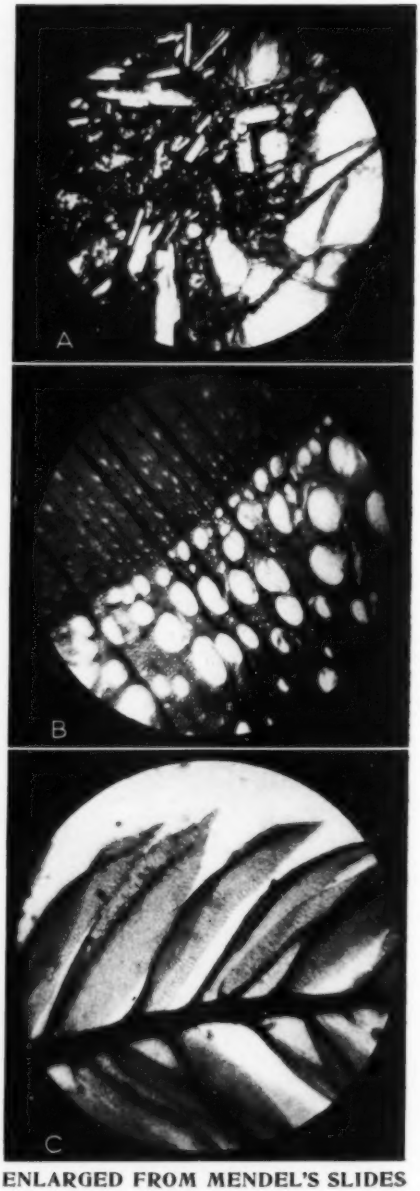
which usually are wider and thicker than the others. In contrast, one can also find polished slide glasses. The width of the slides varies between 18 and 22.5 mm., sometimes reaching 30 mm. The edges often are not parallel so that the glasses are of irregular shape.

The coverslips. In form the coverslips are of two kinds: round and rectangular. Oftenest they are square, but sometimes irregularly oblique. Their thickness varies: the glasses are either thin, just like the modern coverslips, or very thick up to 1 mm. and more. In this latter case they are simply pieces of the ordinary glass used to make the slides, fastened on as coverslips. Evidently most of them were hand-cut, sometimes very evenly and accurately, and others much more roughly. Air bubbles are sometimes found in these also. The dimensions of the coverslips vary considerably, for instance: 12 × 12.5 mm., 12 × 13 mm., 13 × 14 mm., 15 × 15 mm., 17 × 18 mm., 18 × 18 mm., 19 × 19 mm., 19 × 20 mm., 21 × 25 mm., etc. Sometimes the coverslip projects beyond the borders of the slide.

A number, as a rule, is scratched by a diamond point in the lower right-hand corner of the slide. The figures and numbers are generally small, the handwriting appears to be Mendel's. On some of the preparations the figures are larger.

Besides ready-made preparations two small boxes were found, which contained about thirty unused slides of the same type; among these there are some slides of normal thickness, some very thick, wide, narrow, short, longer, smoky, and transparent. All were cut but not polished. Likewise there were found two small, round, flat cardboard boxes containing thin coverslips of various sizes. Most of them were 8 × 8 mm., 18 × 18 mm., and others were evenly or unevenly cut.

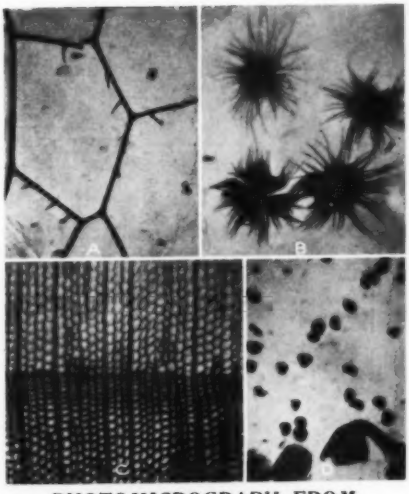
The mounting of the preparations was made by means of Canada balsam. We find labels on the prepara-



ENLARGED FROM MENDEL'S SLIDES

Figure 3

Polished section of an eruptive rock from slide 168, ×25; *B*—cross section of wood of oak from slide 161, ×35; *C*—moss of Hypnum type from slide 166, ×40.



PHOTOMICROGRAPH FROM MENDEL'S SLIDES

Figure 4

A—part of a wing of dragonfly (from slide 135—Figure 2), ×50. *B*—scales of elaegnus (from slide 152), ×60. *C*—cross section of secondary wood of a fir (from slide 114—Figure 2), ×85. *D*—Deformed spores of polypodium with spore cases (from slide 125), ×50. These preparations were made considerably over half a century ago and the excellent detail still visible testifies to the skill of Mendel in microscopic technique. Photographs by the author and A. Gubchezsky.

tions only in exceptional cases, as for example on the two preparations of normal size there are printed labels of white paper with a gold rim. One of the preparations bears an inscription in Mendel's handwriting: "Proc. verm. Kaninchen, verb.", on another: "Leber. Hund". The third, just like the two preceding ones, is not numbered and has on a short, wide, polished slide (54 × 18.5 mm.) a narrow hand-made strip of thick white paper, on which is written "Cattaro 1868". It contains spicules of siliceous sponges.

The general preservation of the preparations, when we take into consideration that they are at least fifty-five years old, is excellent, in some cases remarkable. From some typical preparations microphotographs were taken, which are reproduced herewith and show the detailed structure of the microscopic objects very distinctly. Only a few preparations could not be defined exactly, because of bad preservation. Some others are somewhat doubtful. These are chiefly algae or tissues of higher plants very much dried up and damaged by time. In many other preparations air bubbles were noticed, especially in wood cells, the sections of which are sometimes crumpled or torn. However, in such cases, the air bubbles could easily have arisen during the making of the preparations. Likewise slides and coverslips were found which were cracked, broken, and damaged especially on the edges. Some preparations were evidently remade since one coverslip was found removed from the preparation together with the Canada balsam and with a wood section on it, and in several preparations besides the ordinary numbers, there are also others (for instance on the upper right-hand corner). In other cases the numbers were cancelled with the diamond point (e. g. on preparations: 20, 23, 104, 141, 144, 145, 150). In other cases the coverslip has been applied a second time on the side opposite to that on which the inscription was scratched (e. g. preparations 148, 152).

When we consider the imperfections characteristic of the early days of microscopic technique, one can see that these preparations were made very patiently and with remarkable accuracy. This is evident for instance in the cutting of some of the thin coverslips, especially the round ones; also in the hand polishing of some of the slides, and more especially in the sections of the secondary wood of trees. These sections are triangular in form, the sides of the triangles being 6 to 9 mm. and more in length. Despite the large size of the pieces of wood, the sections in most cases are made throughout remarkably neatly and evenly and some of them are very fine. This is especially astonishing if they are hand-made, which is prob-

able, because at that time special microtomes were not available and moreover no such apparatus has been found among Mendel's belongings.

In all 178 preparations have been found, of which four represent sample preparations used as test objects (the frustules of diatoms prepared by the firm of J. D. Mőller, Wedel, Holstein). Four are French preparations (made by the firms of Ch. Marchand and J. Bourgogne of Paris) which consist of a polished section of the human frontal bone, stained nerves, a stained section of spinal marrow knot (bulbe rachidien du cerveau) and a longitudinal section of a human tooth. Besides these there is a small and very unusual preparation of a female flea in toto, made out of two pieces of slide glass glued together with Canada balsam and fastened together on the border with green paper (dimensions 31.5 × 20.5 mm.). This is the smallest of the preparations found. On its right side is written in ink: "Puce. Femelle". It is possible that this preparation was not made by Mendel himself. Thus we have 169 preparations made by Mendel. Their general numeration is from 1 to 169, but eleven numbers are missing from the series (nos. 1, 4, 5, 6, 7, 14, 16, 33, 101, 151, 158). However, some of these were later on made up by him into other preparations, as for example: nos. 4, 5, 6, 7, 33, 101, because these numbers are to be found on preparations which bear later numbers: 23', 141, 145, 149, 154, 162. Four preparations have duplicate numbers: 23', 53', 154', 156'. Seven preparations bear no numbers at all. Of these, two on ordinary polished slides will be discussed in detail below. According to their contents these 169 preparations can be classified into three groups as shown below.*

Let us now consider the objects somewhat more in detail. Undoubtedly Mendel's chief interest was concentrated on botanical objects, for the majority of his preparations are of this type† (139:30). It is also evident, that his interest was not confined solely to botany, but embraced the microscopic world in general, the living and the non-living. At first he chose for observations all that was easily accessible and did not require any special preparation. Thus we find preparations containing crystals, diatomaceous earth, etc. However, at the same time we find polished sections of

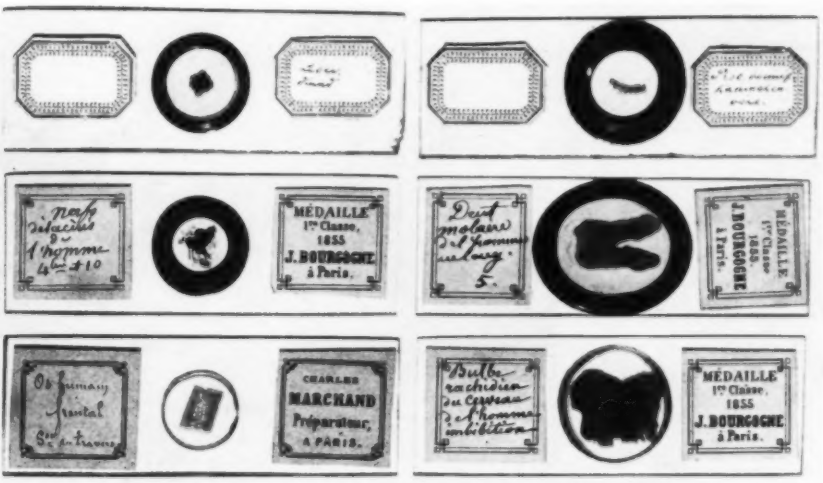
---

* I. Mineralogical and petrographic preparations 9
(Nos. 154, 154', 155, 156, 156', 157, 167, 168, 169.)

II. Zoological preparations 21
(Nos. 19, 121, 127, 132, 135, 137, 139, 140, 141, 142, 143, 144, 145, 147, 148, 149, 150, 165, one without any number, but with an inscription "Cattaro", two without a number, but with labels, see above.)

III. Botanical preparations 139
Among the botanical preparations are:
a. Algae 19
(Nos. 3, 8, 9, 10, 11, 12, 13, 15, 129, 133, 134, 136, 146, 160, 161, 162, 163, two without numbers.)
b. Mosses 3
(Nos. 164, 166, one without number.)
c. Ferns 6
(Nos. 122, 123, 124, 125, 138, 159.)
d. Seed plants 111
1. Parts and tissues of higher plants 8
(Nos. 17, 23, 23', 126, 128, 152, 153, one without number.)
2. Secondary wood of Conifers 13
(Nos. 21, 22, 65, 66, 68, 74, 75, 76, 77, 78, 79, 114, 115.)
3. Secondary wood of deciduous trees 85
(Nos. 24-32, 34-53, 53'-64, 67, 69-73, 80-100, 102-113, 116-120.)
4. Not defined, they seem to be tissue of vascular plants or algae 5
(Nos. 2, 18, 20, 130, 131.)

†At the Vienna University Mendel attended lectures on morphology, physiology of plants, taxonomy and phytopathology (1851-1853).



PREPARATIONS FROM MENDEL'S COLLECTION

Figure 5

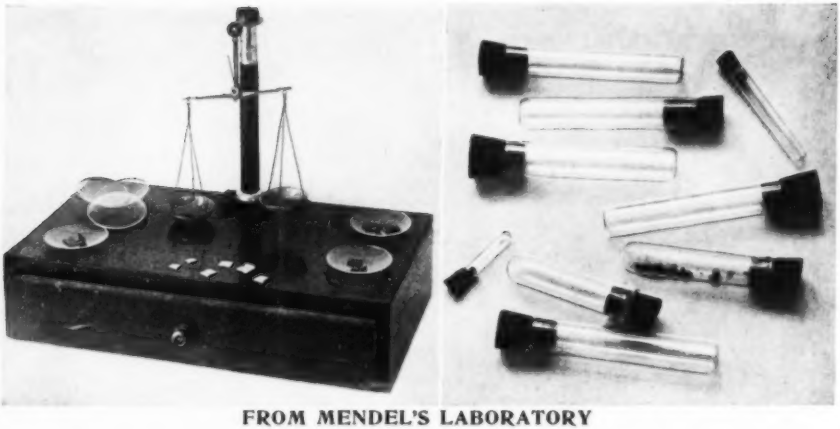
The two upper slides appear to have been made by Mendel, and the remainder are commercial preparations bought from a microscopical supply house in Paris. Only a few of the slides in the series bear evidence of having been prepared by anyone else than Mendel himself. These apparently were bought as a check on his technique.

volcanic rock specimens, the preparation of which calls for a certain amount of practice, accuracy and patience. That these did not escape an attentive examination is proved by the Nicols prisms, found among his belongings. Here we must also mention the collection of small glass tubes with corks, nine in all, in one of which are still preserved dark crystals of some mineral (see Figure 6). Probably these tubes were used for the weighing and preservation of minerals that were being studied.

Mendel possessed also a small apothecary's balance with horn pans which could be attached to a folding stand. Figure 6 shows this balance together with the box in which it was packed with the weights and six watch-glasses. Among Mendel's possessions there was also found a small brush (for pollination of flowers?).

The zoological objects found among the preparations were chiefly scales from butterfly's wings of different form, color, and size; parts of butterfly and dragonfly wings; the antennae of various insects; hairs of animals; radius of a bird's feather; and lastly spicules of siliceous sponges which latter preparations we have already described. Although this last preparation is more than sixty-six years old the objects in it are still quite visible even with a low-power microscope. These are thin, long spicules about 250μ long, 4-6μ thick, sharp at one end and rounded on the other, sometimes bent. In addition to these one also finds other skeletal forms: rod-like bodies and stars of silica, etc.* The inscription on the hand-made label "Cattaro 1868" was evidently made by Mendel himself, though the author so far has not been able to ascertain

*When identifying zoological objects the author was helped by Dr. L. Cernosvitov and Dr. K. Gavrilov, for which help he is much obliged to them, as also to Prof. S. Prát for identifying a few Algae.



FROM MENDEL'S LABORATORY

Figure 6

Chemical balance and glass test tubes found among the effects of Gregor Mendel. One of these tubes still contains dark crystals of some mineral. It is probable that Mendel used the tubes for preserving small specimens of minerals which he was studying. Among his belongings was also found a small brush which may have been used by him in pollinating flowers in his hybridization experiments.

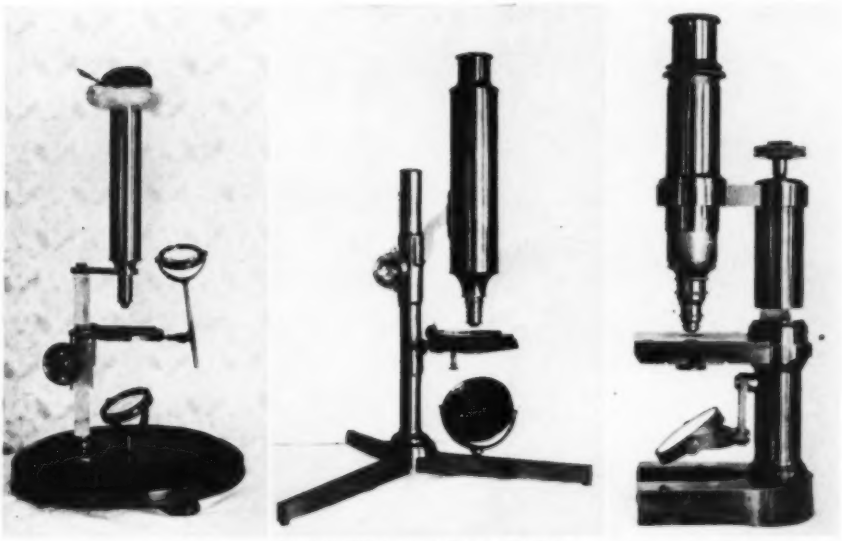
that he visited this town in that year.

An examination of the zoological preparations indicates that Mendel, in preparing them was not guided by any general idea, but chose objects which were easily accessible and favorable for making preparations. The zoological preparations purchased from the firms of Bourgogne and Marchand evidently served Mendel only as samples. We must do him justice that he succeeded in making as good preparations of his own if the two best of those in the collection he left are indeed of his own manufacture. There are a number of reasons for believing that these two preparations are undoubtedly hand-made. First of all is the fact that the slides are of a somewhat different size from the standard glasses used for commercial preparations (77 × 27 mm. instead of 76 × 26 mm.). Furthermore their polish is not so careful as in others, also shown in Figure 2, that were unquestionably made by hand. Finally the form itself and the general character of the labels is very important: small, without a firm name, and, most important of all, in Mendel's own handwriting. These preparations contain stained sections of the vermiform appendix of a rabbit and of a dog's liver. (See Figure 5.)

Among the botanical preparations also we find at first objects that are easily prepared: diatoms, green and red Algae, mosses, a pappus of a Composite, scales of Elaeagnus, bits of tissue, fibers, parts of petals, spores of ferns, etc. However, we think that Mendel, having interested himself in microscopical observations, perhaps by accident during his studies in Vienna*, or during his studies with school boys in Brno†, like the first microscopists, examined anything which was easily accessible to him and from such casual beginnings he may have become a more serious student of the micro-

*Among other courses, he took in Vienna a course in zoology and special exercises in the use of the microscope.

†Mendel taught natural sciences and physics from 1854 to 1868 at the "Deutsche Staats-Oberrealschule" in Brno.



MENDEL'S MICROSCOPES

Figure 7

Three microscopes were found among Mendel's belongings. The dates at which he acquired two of them are not known, but the third one (right) was purchased in the latter months of 1877. His interest in microscopy continued throughout his later years, for he bought newly published books on the subject within five years of his death.

scope. It appears that we have undoubted proofs of this. First of all is the presence in his collection of more difficult technical objects. We find among Mendel's preparations an excellently preserved anatomical-dendrological collection of secondary wood sections of a quantity of deciduous trees and also of fir trees. The cutting of hard wood by hand or even with a primitive apparatus is not an easy matter and here Mendel obtained considerable perfection. It is evident that Mendel was guided in making this collection by Nördlinger's manual "Querschnitte von Hundert Holzarten" (1852), which we find among his books. This is a small, thick box in the shape of a book and containing besides separate leaves of text, also leaves with sections of wood of different plants glued into apertures cut in the paper. It is possible that Mendel studied these wood sections intending to make some comparative researches, though it is also possible that the preparations were made elsewhere, e. g. in Vienna.

However, this is not all. Mendel left three different microscopes and a series of books on microscopy, published between 1867 and 1878. This shows that Mendel interested himself and worked seriously with the microscope, as it is difficult to suppose that the most perfect instruments and the latest editions of books, beginning with the more popular and ending with serious works, were consistently purchased during a period of eleven years only for the amusement of an amateur. At any rate, it is highly probable that whatever work with a microscope Mendel had done previously, he had by 1867 taken a deep and abiding interest in the subject which continued almost to the end of his life. In 1877, only six years before his death,

Bester Freund!

Vor allem meinen herzlichen Dank für die liebenswürdigen Zusendungen, die Sie mir als Autor zuteilwerden ließen. Manches schon zu Gesicht bekommen haben, schon auch in den einzelnen Fällen mich über meine Dankbarkeit schon Ausdruck gefunden hatte.
Sie sind in der Lage des Skeptikers und Beobachters zugleich, während bei mir dagegen so ziemlich das Hypothesenfach Platz findet. Ich habe mich heute bei den Direktoren um vollständige Aufhebung von sämtlichen meteorologischen Beamten verwenden müssen, da ich schon seit Mai vom Herzfehler so sehr und so übel davon bin, daß ich schon fremde Hilfe für meine obliegenden Amtsgeschäfte nicht einmal abzulehnen im Stande bin.
Da wir uns auf diesem Gebiete kaum wieder begegnen dürften, so bleibt mir Ihnen ein herzliches Lebewohl zuzurufen und allen Segen der meteorologischen Hilfsarbeiten auf Ihr Haupt herabzuflehen.

Mit vorzüglichster Hochschätzung für Sie und Ihre geehrte Frau zeichnet sich

Gr. Mendel.

Brünn 20 Dezember 1883

Letzter Brief Mendels an Prof. J. Liznar.

† 6. Januar 1884

A LETTER WRITTEN FIFTEEN DAYS BEFORE MENDEL'S DEATH

Figure 8

This letter is, as far as is known, the next to the last one written by Gregor Mendel. The letter has never been published in full before. It is addressed to Professor Liznar and his notation on the bottom in his own handwriting indicate that Professor Liznar thought that it was the last letter Mendel wrote. It is interesting that the handwriting of this letter, written shortly before Mendel's death from heart failure, differs little from his writings of an earlier date. The original of this letter was kindly put at the disposal of the author by Professor D. Nemec. Photograph by A. Gubitschky.

he purchased a new model of a Reichert microscope,* and in his library are to be found books on the subject issued in 1878. A gradation and a certain system in the study of objects (see list of slides) shows that the great naturalist probably worked with the manuals as a guide, sometimes like a "big botanical practicum," stopping at times also for details. Thus, for instance, we find among the preparations of ferns, six different types of spores. Mendel examined Algae, mosses, ferns, and seed plants. Some objects, as for instance sporangia and spores of ferns and sections of wood were evidently stained which is proved by the traces of yellow color.

The slides in Mendel's collection have a common numbering from 1 to 169: the first numbers up to 15 contain Algae, from 21 to 120 wood sections, the rest of the numbers, as can be seen in the list, are not regular. It appears that part of the preparations were added afterwards, that another part was remade, or the general designation of preparations was made by Mendel later on, when the whole collection was put in order. In Figure 2 are shown several of Mendel's most characteristic preparations, natural size. Figure 5 shows Mendel's two large preparations on polished slides (also natural size) together with four of the slides which he purchased. We must particularly mention two preparations, 23 and 23′ containing parts of white-yellow-violet petals, evidently of a pea flower. Who knows, if these flowers did not come from the series of plants which served Mendel for the discovery of the laws of heredity?

Unfortunately we do not possess any indications whether or not these preparations found are only a part of all the preparations made by Mendel. We must not lose sight of the fact that these preparations are all permanent (Dauerpräparate) which does not exclude the possibility that Mendel also made and studied temporary preparations especially of lower organisms. That a microscopist of his experience should have confined his observations to this series of slides is obviously extremely unlikely. A careful examination of Mendel's microscopes also indicates that they were not in the hands of a simple amateur; they had accessory fittings for making preparations, Nicols prisms, micrometers for measurements, an immersion objective allowing an enlargement of 1500×, etc.

Gregor Mendel's Microscopes

Among Mendel's effects were found three microscopes. It is not known when he acquired two of them, but the third was purchased, as noted above, in 1877. The simplest of these instruments (Figure 7) is a microscope of somewhat primitive construction marked "Plössl" Vienna. It is mounted on a round wooden base. The mirror is attached to the base, apart from the microscope stand. The stage moves by means of a head and a rack and pinion. The body-tube is immovable with a draw tube at the top. Attached to the stage is a separate and removable lens. (Sammellinse) for concentrating the light on the lower mirror and acting thus as an original condenser. There is no real iris-diaphragm. Three objectives, successively screwed one on another, allow an enlargement from 33× to 150×. A velvet cap with a border of fur and feathers serves to protect the ocular from light and dust.

The second microscope in order of technical refinement (Figure 7) is a very large folding microscope on a brass tripod-stand, with an unusually high and wide tube which moves with the help of a rack and pinion. The fine adjustment is operated by a milled head. The mirror is attached to one of the legs of the tripod. There is a sliding movable stage (Kreuztisch) and there are two oculars. The microscope folds up in a large box. The apparatus is fairly exact and sensi-

*According to information from the firm of C. Reichert—M. Wondrusch this microscope was sold in the second half of 1877.

tive. It also has a feathered cap. Special pins, which can be taken off, are fastened to the microscope-stage, to which is attached a side magnifying lens, a preparing needle and a special forceps in the form ot a drawing pen opening upon simple pressure. This complicated and interesting adaptation served evidently as a preparatory instrument, being a kind of prototype of a primitive micromanipulator.

The Reichert microscope, model No. 3, ordinal No. 37, is distinctly a more modern instrument. It has a height in all of 26 cm., with a brass stand and a horseshoe-like foot. The coarse hand adjustment is accomplished by sliding the tube but it has a fine adjustment actuated by the single milled head. The movable mirror is attached to the stand; the concave side is well preserved; the flat side much damaged. The stage is not movable, and is without any real iris-diaphragm. Oculars: O, II, V. Objectives: 3, 5, 7, IX immersion. Enlargement up to 1500×. Ocular micrometer.

Gregor Mendel's library contains the following books on microscopy:

1. Jäger, G., *Die Wunder der unsichtbaren Welt enthüllt durch das Mikroskop.* (A popular edition.) Berlin, 1867.

2. Vogel, J., *Das Mikroskop.* L. Denicke, Leipzig, 1867.

3. Merkel, F., *Das Mikroskop und seine Anwendung.* München, 1875.

4. Willkomm, M., *Die Wunder des Mikroskops.* IV. Auflage, 1878.

Also, among other technical books, the following manuals on botany, often with marginal notes by Mendel:

1. Endlicher und Unger, *Grundzüge der Botanik.*

2. Schleiden, *Grundzüge der wissenschaftlichen Botanik,* 1847.

The greater part of Mendel's preparations have at present no scientific value. The fact that he made microscopic preparations is very interesting and proves that the general enthusiasm of naturalists for microscopic studies had also a considerable influence on him. This new chapter in his activity bears witness to the variety of his scientific interests and particularly to his special inclination toward botany. It also shows the breadth of his scientific horizon. Who knows, if Mendel had lived a few years longer would he not have enriched science with a new and ingenious law in the sphere of the anatomy of plants?

✣

Uniting Science and Religion

THIS volume* consists of a series of lectures given at the University of Aberdeen, covering the field of science, matter, space, theory of space, space-time, general relativity, electrical theory of matter, heat and light, quantum theory and Roentgen rays, astronomy, origin of life, evolution of plants and animals, man's origin, God and belief in his existence, religious experience and immortality. The material is up-to-date in all the branches of science included in the book. In parts of the book the author assumes a training in mathematics which very few possess. It is nevertheless a satisfaction to find any book so accurate in so broad a field, a field in which religious leaders need a volume to which they can turn as authoritative.

Bishop Barnes has entered into the spirit of the scientific leaders whose lives are given to finding the principles that govern the universe. He finds their spirit like his own and feels the need of an understanding between those searching for truth and those teaching a way of life which includes disciplined and practiced spiritual life in a world not yet fully living up to the truth already at hand.

George M. Darrow
U. S. Department of Agriculture

*Barnes, E. W., *Scientific Theory and Religion.* Macmillan Company, New York, 1934.

X-RAY INDUCED MODIFICATIONS OF FLOWER COLOR IN THE PETUNIA

C. N. Moore and C. P. Haskins
Research Laboratory, General Electric Company

RATHER widespread interest has recently been exhibited in the occurrence of gene mutations in organisms subjected to x-irradiation from the standpoint of their frequency of distribution as a function of dosage (essentially as a function of the number and distribution of electrons released within the tissue). Such data, when treated according to the method developed by Dessauer, Crowther, Curie, Wyckoff and others, for the study of the rate of "death" of unicellular organisms under radiations, may be capable of yielding an expression for the minimum radius of the gene in question, the assumption being made that the occurrence of mutations follows a probability distribution because of the random distribution of absorbed quanta. In order to conduct experiments in gene mutations under these conditions which shall be of statistical significance, a very large amount of material indeed must be used if germinal cells only are to be considered because of the low rate of mutation at a single locus even under x-rays. Patterson's work* in the production of mosaic patches in the eyes of *Drosophila* adults rayed as eggs and young larvae has demonstrated the possibility of inducing somatic mosaic tissue mutation, thereby increasing the probability of mutation in a given individual by the number of suitable somatic cells present at the time of treatment. That data so obtained are entirely suitable for the usual probability calculations seems to be indicated by work of Haskins and Marshak.†

Such a situation may render any material of considerable interest in which mutations in somatic tissue can be produced under x-irradiation such that patches of modified tissue will appear in the mature organism, corresponding to modified single cells in the tissue as rayed, and readily distinguishable from the normal background. In this connection the following experiments are considered worthy of record, as indicating material of possible interest to students in the field.

It was the purpose of the investigation described to determine the effect of x-rays of moderate hardness upon somatic variations in the flower of the petunia, following upon irradiation both of the flower bud itself and of the seed from which the mutant plant was produced. The experimental material for the work was kindly furnished us by Dr. Ernest Dale, of Union College, Schenectady, N. Y.

Material Used

The first stock used for the experiments in bud raying was a pink and white petunia of uniform petal coloration (see Figure 9, upper left) representing a cross between stocks bearing respectively white and ivory pollen but of the same petal color. The pollen of the resultant cross was blue, and it was in the modification of this pollen color that we were originally interested. It remained constant throughout. The plants were all normal diploids ($n = 7$, $2n = 14$). The stock described will be referred to as No. 634.

Several other stocks were also used. Stock No. 635 was a diploid strain of pure magenta flower color, normally stippled with fine white dots, representing clusters of but three or four colorless cells, derived from diploid parents of different background flower coloration but apparently the same type of

J. Exp. Zool. 53: 327-371 (1929)—*Journal of Heredity* 20: 261-7, 1929.
†Unpublished.

CYLIC COLOR VARIATIONS PRODUCED BY X-RAYING BUDS

Figure 9

Flowers from a branch of a Petunia plant of line 634 which was exposed for one minute to X-rays (85kvp., 10ma., at three inches). Exposure took place 10-12 days before the flower at the upper left opened. The remaining flowers opened at intervals of about four days and the different patterns are due to the state of development of the bud at the time of exposure to X-rays. Thus the second flower to open (top center) was nearly mature and the mutational effect is shown as small dots, as each mutant cell had only a few descendants. The third flower was less developed and the cells arising from mutants had more descendants and the resulting mutational spots are larger. Later flowers show entire colored sectors for the same reason. (After a painting from life by G. E. Artist Staff.)

stippling. Stock No. 662 was a diploid, bearing a flower of red background color streaked with irregular patches of white variegation, caused apparently by the presence of masses of colorless and air-filled cells. It also was derived from parents of different flower background color but bearing apparently the same type of variegation. Both of these stocks were believed homozygous, respectively for stippling and variegation.

The F_1 stock of the cross between them will be referred to as No. 16, when the plant supplying the pollen was No. 662, as No. 20 in the reciprocal cross.

Stock No. 854 was a diploid type, of rather pale pink flower color, without stippling and derived from non-stippled parents. Stock No. 857 was of clear pink background, with a fine white stippling, which had behaved as a dominant, since it was derived from the F_1 generation of a cross between a normal and a similarly stippled plant. Stock No. 24 was a plain pink diploid, derived from a plain and a brokenly variegated plant, the variegated character being completely recessive in the F_1. Stock No. 25 was a plain pink diploid, derived from plain pink diploid parents. Stock No. 1053 was a pure, selfed strain, of a plain dark magenta in coloration, entirely without stippling or variegation. These stocks, and the F_1 plants derived from them as will be indicated, represented the principal material used in the experiments both in bud and seed raying.

Sources and Character of Radiation

The source of x-rays used in bud raying was a Coolidge "Portable" air-cooled tungsten-target tube, provided with a thin, soft-glass window—the remainder of the tube being of lead glass. The tube itself being self-rectifying was operated directly from the high-tension transformer. It was operated throughout the experiments at a voltage of 85 kvp. and a current of 10 ma., focal distances of three and six inches being used. Under these conditions, the total incident energy inputs were respectively 636 and 318 rontgens per minute, as measured directly with a Failla radium-compensated graphitized-collodion-wall ionization chamber. The greatest intensity of radiation lay in the region of the $K\alpha$—$K\beta$ doublet for tungsten, between 0.21 and 0.18 A.

It is well known that the dry seeds of most plants, in common with the resting or encysted forms of microorganisms, are capable of withstanding much larger dosages of x-ray energy without visible alterations than is tissue in which mitosis is actively taking place. For this reason, it proved more convenient to apply much higher x-ray dosages in the work in the raying of seed than in that concerning the buds.

For this work, therefore, the source of radiation used was a standard Victor deep therapy outfit, comprising a high tension transformer with cross arm mechanical rectifier of the Snook type as the high voltage generator and a standard Coolidge water cooled tungsten target tube of the thick walled type. The tube was operated at 200 kvp. and 30 ma. the seed being exposed at a focal distance of 4.5 inches. The incident energy output of the tube, as measured with the ionization chamber already described, was 3.0×10^3 rontgens per minute. The greatest intensity of radiation, as in the previous case, lay within the region of the $K\alpha$—$K\beta$ doublet for tungsten.

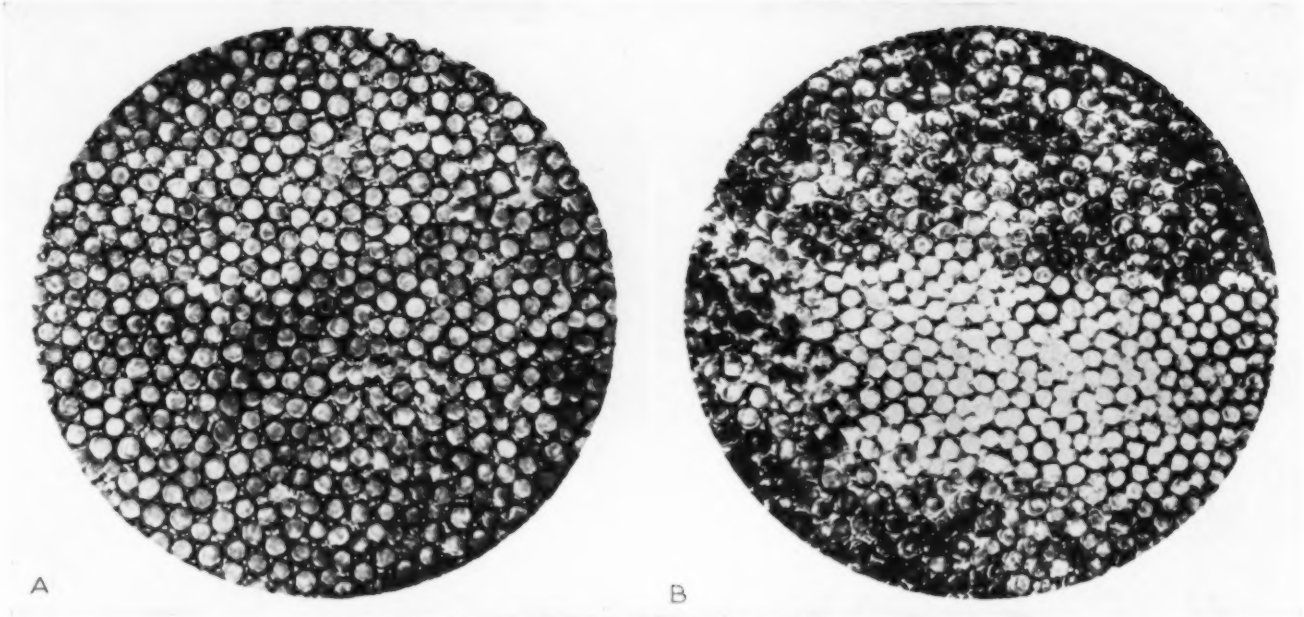
Procedure

Potted plants of the petunias in question bearing buds in various stages of development were laid upon a wooden table, and the entire specimen except a single branch thoroughly covered with lead sheeting, so as to be entirely protected. It was thus possible to maintain x-rayed and control tissues on the same plant. The branch to be treated was given a single exposure of from one to four minutes, and the plants were returned to a greenhouse and cultured. Examinations and records were made of all flowers as they appeared.

Results

Raying of Buds

A very regular cyclic order of flower variation was obtained with the plain pink stock No. 634, as shown in the



MOSAIC COLOR PATTERN IN STIPPLED REGION OF PETAL

Figure 10

Two photomicrographs of petal surface from flowers from X-rayed branch of stock number 634. These photographs show the mosaic character of the petal coloration in the stippled regions. This is due to the somatic mutations in flower color caused by the X-ray treatment.

accompanying figure and Table I, representing the complete results of an experiment on a single plant. The first two flowers which opened on x-rayed tissue after its treatment were in most cases perfectly normal in appearance. Usually the third flower exhibited a fine white stippling, caused by the presence of a large number of colorless cells or groups of few cells, as shown in the accompanying photomicrograph of a portion of the affected petal tissue. In succeeding flowers the numbers of cells composing these groups became progressively larger, as illustrated, so that the flowers became coarsely flecked with white. In the sixth or seventh flowers, the white flecks became less numerous, and fine white lines appeared radially. These rapidly increased in breadth in succeeding flowers, becoming wedge-shaped patches in the eighth or ninth blooms, the background having returned to the normal coloration. Succeeding flowers were perfectly normal in color, and no subsequent morphological variation has been detected unless the plant were again irradiated. It is very interesting that the effect can apparently be repeated with this stock, the general character of the cycle being, so far as noted, invariable. It was found possible to maintain a constant effect by irradiating a flowering branch at the maturing of every fourth bud. At no time did the flowers from shielded tissue on the same or other plants show any effect whatsoever.

The progressive character of this effect might rather be expected, assuming that, at the younger stages of the bud, fewer primordial cells are present to be affected, from which larger groups of modified cells will be descended. Table I is a summary of an experiment on Stock No. 634, involving only three branches of a single plant. All exposures were made at a window distance of 3 inches (input 636 r/min.).

This illustrates quite clearly the cyclic nature of the response. Branch No. 3 produced a number of side shoots, which bore flowers affected as shown in Table II.

TABLE I. Condition of Flowers on Rayed Branches

Branch No.	*Time of Exposure (Min.)*	*Days elapsed before maturation of flower*	*Flower Number*	*Condition*
1	3	9	1	Normal
1	3	12	2	Normal
1	3	15	3	Many small white flecks
1	3	19	4	Many white flecks
1	3	21	5	Ditto
1	3	26	6	Several long white streaks
1	3	32	7	One large white Wedge. Background normal
1	3	35	8	Normal
1	3	41	9	Normal
1	3	42	10	Normal
2	2	7	1	Normal
2	2	12	2	Normal
2	2	15	3	Many white flecks
2	2	19	4	Ditto
2	2	22	5	Ditto
2	2	26	6	One broad white patch
2	2	32	7	One broad long white wedge. Background mottled pink and white.
2	2	35	8	Normal except for two rectangular white patches
2	2	41	9	Normal
3	1	7	1	Normal
3	1	12	2	Normal
3	1	14	3	Normal
3	1	15	4	Many white flecks
3	1	19	5	Ditto
3	1	21	6	Less numerous white flecks
3	1	26	7	A few white lines
3	1	27	8	One broad white patch; two long white lines
3	1	31	9	Normal
3	1	33	10	One small white fleck
3	1	36	11	Normal
3	1	41	12	Normal
3	1	42	13	Normal

TABLE II. Flowers on Shoots of Branch No. 3

Branch No.	*Flower No.*	*Condition*
1	1	Normal
2	2	One white wedge, two white lines
2	3	Normal
2	4	Normal
2	5	Normal
2	6	Normal

Exposures above three minutes were lethal. The lower dosages produced the variation in 100 per cent of the attempts made.

Stock No. 634 was homozygous for absence of stippling or variation, as has already been mentioned. The effects described were by no means confined to stock of such composition, however. Thus stock No. 20, heterozygous for both stippling and variegation, but itself plain, showed the identical cycle for *variegation* in the x-rayed bud tissue, the variegation being white, or, in two cases, white and purple. Since the background flower color was magenta, the indication that only red pigment was suppressed in these variegated areas was strong. F_1 stock of No. 857 × No. 854, heterozygous for pink stippling, gave rather large white patches in the same cycle under x-irradiation. Stock No. 24, plain pink in color and heterozygous for white variegation, showed white and purple variegation somatically induced. Stock No. 25, homozygous for plain pink, showed white variegation in the same cycle. Stock No. 1053, a pure strain for absence of stippling, as already described, gave pink variation, the background color being a plain dark reddish purple.

It is evident that, at least in certain cases, these somatic modifications are reasonably independent of the genetic constitution, and represent the independent suppression of one or more of the pigments of certain of the petal cells responsible for the final flower color. In a few cases, seeds grown from selfed flowers showing the variegated areas have produced plants whose own flowers were variegated (this was notably true in the case of No. 634, in which 2 of 37 plants grown from seed set by selfed modified blooms produced modified blossoms in turn) but in general this was not true. Because of the complex situations of partial dominance and modifiers which arise in the petunia and the generally unsatisfactory nature of petunia sex cells as cytological material, these results cannot be given a genetic interpretation at present. They do seem of considerable interest, however, as material in which it is possible to expose large sheets of embryonic tissue composed of very similar cells possessing a readily determinable criterion of modification, to x-rays for statistical study of x-ray action in the modification of single units. Further developmental work should be carried on in this connection.

Raying of Seed

The raying of petunia seed offers a similar opportunity to affect primordia of various types of tissues with x-rays in a larger population in such a fashion that the results may be readily visible. It possesses an advantage over the irradiation of buds in that the chance is greater that germinal centers may be affected, permitting a better genetic analysis of the results. This virtue is offset, however, by the very much larger population which must necessarily be handled if the same total number of cells is to be involved in the experiment. The percentage affected is likewise much smaller. Thus 1,000 plants were grown in the F_1 generation from crosses of Stock No. 635 × Stock No. 662, which as seed had been exposed for six minutes to the radiation of the high voltage tube under the conditions already described. Of these plants, 1.6 per cent showed variegated flowers throughout, the stock being of course heterozygous for both variegated and stippling; 48 per cent of the stock showed stippling. The control, of which 600 plants were matured, showed no variegation, and 44 per cent of stippling. A total of 541 of the F_1 plants were backcrossed to both parents. Of these, 206, or 38.1 per cent, showed variegation, and 81, or 33.5 per cent, stippling, while none showed both characters. A total of 329 plants in the F_2 generation were grown from selfed seed, yielding 66, or 20.1 per cent, which were variegated, 74, or 22.5 per cent, stippled, and 8, or 2.4 per cent, which showed both markings in identical flowers of the same plant. No comment should be made on these

ratios, but it is interesting that the characteristics are recoverable in the F_2 generation.

More attention should be devoted to the phenomenon of induced stippling and spotting in this flower, as a resultant of bud and seed raying, both as a tool in the investigation of the mechanism of gene mutation and from the standpoint of an aid in the elucidation of the somewhat difficult genetics of the petunia.

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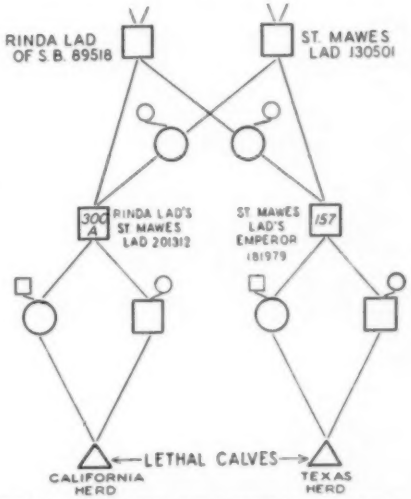
RELATIONSHIP BETWEEN HAIRLESS CALVES IN CALIFORNIA AND TEXAS HERDS

THE two articles on hairless calves, which follow this note, represent independent discoveries of the same gene in two widely separated herds of registered Jerseys. The contribution from California was submitted to the JOURNAL first. A few weeks later a letter was received from Dr. Horlacher regarding publication of a manuscript describing an apparently identical defect. Through the courtesy of Dr. Mead and his co-workers, it was arranged to publish these two articles in the same issue of the JOURNAL, so that the subject could be completely disposed of at one time, and the interesting interrelation of the defects in these two herds brought more forcibly to attention.

When a study is made of the pedigrees of the two "suspect bulls" in the California and Texas herds it becomes clear that we are not dealing with a case of parallel mutation but with two appearances of the same defective gene. In the pedigrees of these two bulls (No. 300A and No. 157) at least two common ancestors are found in the first four generations. Saint Mawe's Lad, 130501, the sire of the Texas bull, 157, is the grandsire of the California bull, 300A. Rinda Lad of S. B. No. 89518, the sire of the California bull is the grandsire of the Texas bull. This situation is shown diagrammatically in Figure 11. (Some inbreeding to other ancesters not common to the two herds being neglected). Undoubtedly one or the other of these two bulls was heterozygous for the hairless gene: both of them may have been. The considerable linebreeding of Rinda Lad of S. B. 89518 shown in Mead's two detailed pedigree charts (Figures 13 and 14) might well be taken as almost conclusive circumstantial evidence that



RELATIONSHIP OF LETHAL CALVES IN TWO HERDS

Figure 11

Summary pedigree chart to show the relationship of the hairless calves which appeared in herds of Jersey cattle in California and Texas.

this bull carried the gene in question. The evidence from the Texas herd would seem to point just as strongly to St. Mawe's Lad as the "guilty party." In this herd with less relationship to Rinda Lad, and a closer relationship to St. Mawe's Lad the same defect has appeared. All the evidence presented makes it difficult to convict either bull, though the articles from Texas and California published separately might have convicted both of them of "harboring a deleterious gene."

No matter which way the final verdict goes the matter has another very interesting angle. Both of these bulls have been prominent sires in the de-

velopment of the Jersey breed in this country. Each of them has added to the high production potentialities of that breed if we are to judge by their records. Saint Mawe's Lad has 55 registered daughters, and 22 of them are listed in "Tested Sires of the Jersey Breed" as having had an average annual butterfat production of 821.33 lbs. (mature equivalent). Rinda Lad of S. B. has 62 registered daughters, and 47 of them have passed production tests, making a record of an average annual butterfat production of 665.10 pounds (mature equivalent). Furthermore, both bulls come from high producing families and have sons and brothers which have sired high producing cows. Thus it is clear that the genes these bulls carry are very widely disseminated throughout the Jersey breed in this country. The situation is an excellent example of the "paradox of lethal genes and great sires" discussed by the late Christian Wriedt some years ago.* Wriedt calls attention to several cases in which outstanding sires, with a profound effect on breed development, have also been carriers of lethal genes. These have been very widely disseminated in the descendants of those sires along with the genes for the desirable qualities which made these sires famous. Even though their popularity has resulted in the wide dissemination of lethal genes it may still be questioned whether the extended use of these sires has not been an advantage to the breeds in question. It is perhaps unfortunate that a critical survey† of the lethal problem published in 1931 has not been more widely noticed. Berge makes it clear that with few progeny elimination of "lethal carriers" is extremely difficult.

An evaluation of the losses caused by such a defect and of the gains through a happy combination of desirable characteristics (such as is found in a great sire) is a complicated problem in livestock economics. Unless there is rather close linkage between the high producing genes and a lethal gene in a particular sire, there is of course no reason why among his descendants superior individuals should be more frequently carriers of these recessive defects than are less desirable animals.

The evidence that we are dealing in these two herds with the same gene is conclusive. There still remains a question whether the hairless gene in the Holstein breed reported by Hadley is identical with this lethal gene in the Jersey breed. This could only be proven by crossing a heterozygous Holstein and a heterozygous Jersey. If defective calves were born we would have conclusive evidence that the same gene is involved in the two breeds. If a large number of normal calves was produced we could conclude with some certainty (depending on the number of calves) that different gene loci were involved. Extensive *inter se* matings between these hybrid calves would be necessary to prove this point. It seems hardly likely that this rather expensive bit of research will be undertaken. The existence of at least two "Waved-hair" genes in the mouse, identical in appearance but genetically distinct (to cite but one example from mammalian genetics) suggests that more than one "hairless-1" gene may exist.

Should the production of defective calves by such a mating prove the same gene to be present in the two breeds, the question of the origin of the mutation presents a further problem. The importation of cattle to the Island of Jersey for breeding purposes has long been prohibited. According to some authorities this ban has been effective for five hundred years. Such barriers are rarely perfect, and some "bootlegging" of breeding stock across the English Channel from the homeland of the Holstein Friesian breed in Holland may well have occurred. The possibility of a reciprocal transfer of Jersey cattle to Holland is perhaps greater because Jersey cattle have long been sent to many parts of the world. The suggestion by Atkeson and Warren in the August JOURNAL that the wrytail character is most common in Holsteins and Jerseys may also indicate a certain community of genes in the two breeds in spite of their different color patterns.—EDITOR.

*WRIEDT, CHRISTIAN, *Heredity in Livestock*. Pages 127 ff. Macmillan, 1930.
†BERGE, S. *Zeit. fur Ind. Abs. u. Vererb.* 58:157-165. 1931.

AN INHERITED SKIN-DEFECT IN CATTLE

The Occurrence of a Sub-Lethal Epithelial Defect in a Jersey Herd, and a Plan for Eliminating Lethal Genes

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BECAUSE of the widespread interest in the hereditary improvement of dairy cattle, several experiments designed to study the mode of inheritance of the characters responsible for milk secretion are now in progress. One of these, designed to fix the characters for high production through inbreeding, is being conducted with the Jersey herd at the California Agricultural Experiment Station at Davis.

This paper reports a recessive sublethal defect, hairlessness, which has made its appearance in one of the inbred families. So far as the authors have been able to ascertain, this is the first report of the occurrence of this defect in the Jersey breed.

Investigations in animal breeding during the past decade reveal a considerable number of recessive lethal genes in all classes of domesticated livestock. At least eleven, as summarized in Table I, have been reported in cattle. Although it is impossible to state how extensively these are disseminated throughout the breeds of cattle, a rapidly accumulating mass of evidence supports the belief that they are quite generally distributed in all the modern breeds. $Hairless_1$, for example, is found in both Holsteins and Jerseys, whereas the lethal factor muscle contracture is found in American Holsteins and several European breeds.

In all probability, the recessive lethal genes lately reported are not the result of recent mutations, but occurred long before the present breeds were established. Since mutations are relatively rare, it is reasonable to believe that once a line is purged of recessive lethals and only descendants of purged animals are used in propagation, the line should remain free indefinitely.

Hereditary defects have remained hidden in cattle chiefly because of the strong aversion to inbreeding caused originally by the appearance of hereditary defects. The use of the progeny test to evaluate a sire's transmitting ability for production is now being advocated by all dairy-breed associations and by many educational agencies. Dairymen not only are being advised to retain bulls that transmit high production throughout their reproductive lives but are being urged to follow with sons of such bulls. As a result of this so-called proven-sire campaign, inbreeding will be practiced to a much greater extent. The consequence will be a more frequent segregation of recessive lethals to the homozygous state. Not all these defects will be discussed here, since Hutt[4] has recently made a rather complete review of the subject. We will, however, mention defects that may be confused with the one herein reported.

The first hereditary hair defect reported for cattle was that described in 1919 in Holsteins by Cole.[1] The hair was short at birth, but later became practically normal. The condition was accompanied by the absence of one or more incisor teeth, those present being somewhat rudimentary and imperfectly formed. Later Hadley[3] reported the inheritance of a sub-lethal, hairless defect in Holsteins, which he called "Epitheliogenesis Imperfecta Neonatorum Bovis." In these cases the skin was absent below the knees and hocks and on the muzzle; ears were deformed because of rolling of the margins and adhesions of the contacted surfaces. There were also defective areas in the mucous membrances of the nostrils, tongue, hard palate, and cheeks. One

HAIRLESS CALVES

Figure 12

Hairless$_1$ is a recessive, sub-lethal, epithelial defect found in Jersey cattle. Four hairless$_1$ calves were produced by paternal brother and sister matings. Three had the same general appearance as the calf shown in the upper photograph. The head shown below is that of another hairless calf. In the latter the condition of the lower jaw may have been the result of surgical delivery.

or more hoofs were absent or incompletely developed. All calves died shortly after birth.

Another sub-lethal hair defect (Hypotrichosis Congenita), also found in Holsteins, was reported by Mohr and Wriedt[5] in Norway; but the absence of hair was more general, hair appearing only around the eyes and the muzzle, over the horns, and around the umbilicus, the external genitalia, and the distal parts of the tail. Also, in contrast to the cases reported by Hadley, there was no absence of skin. The calves lived only a few minutes.

Craft and Blizzard[2] have recently found in Polled Herefords another hereditary defect that influences the development of hair. This condition, recessive but not lethal, is called semi-hairlessness. The skin is intact, with only local areas deficient in hair. Lack of vigor and subnormal growth accompany the hair defect.

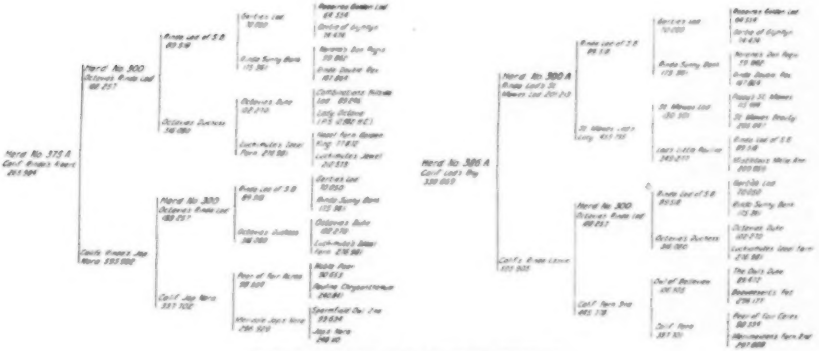
Since Hadley[3] has priority on the use of the term "hairless" in describing a defect, Epitheliogenesis Imperfecta Neonatorum Bovis, caused by a specific gene, and since Mohr and Wriedt have used the same term to describe another defect, Hypotrichosis Congenita, which is genetically different, we will, in order to avoid the possibility of confusion, designate the type described by Hadley as hairless$_1$ (hr_1) and that of Mohr and Wriedt as hairless$_2$ (hr_2).

Of the hereditary epithelial defects so far cited, only the one described by Hadley (hr_1) in Holsteins appears to be identical with the one herein reported for Jerseys.

Four hairless calves were produced (Figure 12), including three females and one male. Two of the females and the male were born alive; parturition appeared normal, though all three were born two to three weeks early. The

TABLE I—Recessive Lethal Defects Found in Cattle[4]

Defect	*Description*
1. "Bull-dog$_1$," dexter	Dominant achondroplasia; Homozygous dexter lethal
2. "Bull-dog$_2$"	Recessive achondroplasia
3. Hairless$_1$	Parts of integumentary epithelium absent
4. Hairless$_2$	Epithelium intact but almost completely devoid of hair
5. Amputated	Distal portions of limbs absent
6. Short spine	Vertebral column defective and shortened
7. Mummified foetuses	Neck short and stiff, prominent joints; usually die during eighth month of foetal life
8. Lameness in hind limbs	Calves unable to stand on hind legs
9. Muscle contracture	Muscles of neck and legs strongly contracted
10. Ljutikow's lethal	Legs short; digits sub-normal and often fused
11. Ankylosis of the lower jaw	Lower jaw shortened and immobile



PEDIGREES OF HERD SIRES

Figures 13 and 14

Bull No. 300 was the first sire used. At his death he was followed by his son, No. 375A. That bull 300 did not carry the hairless factor is indicated by the fact that his inbred son, 375A, sired no hairless calves when mated to the daughters of bull 300.

Three of the four bulls used in the breeding experiment are represented in this pedigree. Of these, 300A and 386A are definitely known to be heterozygous for the hairless factor. When 386A was bred to eight daughters of 300A, he produced four hairless calves.

fourth calf, which presented a serious case of dystocia, had died *in utero*. Delivery was accomplished, three weeks before term, through fetal surgery. All the calves had the same general appearance: not only were parts of the body hairless, but there was no skin below the knees or hocks, around the eyes, or on the muzzle. In two cases skin was present below the hips only in small patches. Local areas in other parts of the body were devoid of skin. In all cases one or both ears were deformed; and with two the ears were inverted, forming adhesions with the epithelium covering the head. Two of the females were carefully examined. The anus of one was completely closed. The other had no vulva or posterior opening of the vagina; urine from the bladder, unable to escape, had passed through the cervix and distended the uterus, widely dilating the cervical canal. The uterus contained about a liter of urine. The vagina, though apparently normal, had no external opening. Of the three calves born alive, one lived six hours; the other two were destroyed about 15 hours after birth. None of the calves was able to stand, and no attempt was made to induce them to nurse. All appeared normal in size for the breed.

The hairless calves appeared in one family of purebred Jerseys used in the inbreeding experiment in which sire-to-daughter matings have been practiced. In the event of the death of a sire, the most closely related bull available has been chosen in his stead. The first sire used was No. 300. He had twenty-nine normal offspring, six being from six of his own daughters, the remainder from unrelated foundation cows. Sire 300 was followed by his 75 per cent son, No. 375A (Figure 13), who unfortunately died at an early age. He was bred to four unrelated cows and three daughters of his own sire,

TABLE II. Related Matings Which Produced Normal and Hairless, Offspring.

Bull	Related Cows	Offspring			
		Normal		Hairless	
300	6 own daughters	4	2	0	0
375A (75% son of 300)	5 daughters of bull 300	0	3	0	0
300A (Paternal brother of 300)	5 daughters of 300 3 daughters of 375A	6* 4	3 1**	0 0	0 0
386A (Son of 300A)	1 daughter of 300 0 daughters of 375A 6 daughters of 300A	1 1 3	0 2 6	0 0 1	0 0 3

*Two heterozygous cows were sired by bull 300A when outcrossed to unrelated dams.
†Heterozygous bull 386A is included in this group.
‡One heterozygous cow was produced in this group.
**Heterozygous cow.

No. 300, each producing a normal offspring. After the death of 375A, the most closely related bull then available was 300A, a paternal brother of sire 300 and out of a maternal granddaughter of the sire of both 300 and 300A (Figure 14). This third sire produced thirty-one offspring, all normal; nine of these were from five daughters of his half brother, 300; five from three daughters of the 75 per cent son of 300; and seventeen from twelve unrelated cows.

Sire 300A was followed by his son, 386A (Figure 14) out of a daughter of 300. This bull, the present herd sire, has had nineteen offspring from eleven related cows: a daughter of sire 300 had one normal calf; two daughters of 375A gave five normal calves; but eight daughters of his own sire produced thirteen offspring, four of which showed the characteristics of hairless$_1$.

The data assembled in Table II are convincing evidence that sire 300A was heterozygous for hairless$_1$ (Hr_1 hr_1), since his daughters produced four hairless calves when mated to his son 386A. That the daughters of 300A, or his son 386A, did not receive the factor for hairless$_1$ from sire 300 is indicated by the fact that when 300 was mated to six of his own daughters, only normal calves resulted; further, his 75 per cent son, when mated to three of his daughters, produced only normal calves. His daughters produced no hairless calves when mated to their sire's half brother, 300A, the bull that later proved heterozygous. This conclusion is further strengthened by the fact that the four daughters of 300A which produced hairless calves were from four different dams, two of which were not related to sire 300.

The mating of a heterozygous bull (386A) with daughters of a heterozygous bull (300A) out of what we may safely consider homozygous normal cows, resulted in 9 normal and 4 hairless calves; as contrasted with the theoretical expectancy of 11.4 normal and 1.6 hairless. Considering the small numbers involved, the observed and theoretical values are in fair agreement.

A "Lethal Purging" Program

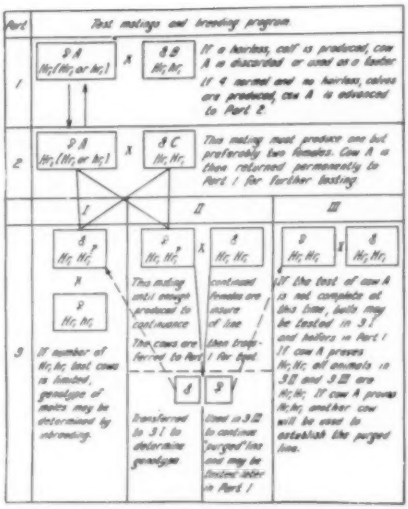
Because of the losses that will accompany the outcropping of lethals, it is important at this time to investigate the possibilities of purging families in which high production has been rather well fixed. A breeding program to purge our Rinda Lad family of Jerseys of the recessive lethal hairless gene, has been undertaken at this Station.

In our long-time experiment, sire-to-daughter mating is practiced. When a bull is no longer serviceable, his most highly inbred son from a cow possessing desirable type and production is selected to take his place. The productive capacity of all females is determined within our own herd under uniform environmental conditions. Male offspring are lent to cooperating dairymen in order to determine their transmitting ability for both production and defects.

A genetic assay is made on the basis of the progeny test. The dam-and-daughter comparisons are used in evaluating the transmission of production factors, whereas the presence or absence of undesirable recessive genes is established, according to the method suggested by Wriedt,[6] by breeding each bull to twenty of his own daughters.

When it became evident that certain animals carried the recessive lethal gene hairless$_1$ we began the purging program described in the following pages. Although similar programs have been used successfully with laboratory animals and plants, we nevertheless realized the many difficulties involved in applying such a program to dairy cattle. Inbreeding has given us an intimate knowledge of the genetic make-up of the animals involved, thus reducing the probability of perpetuating one lethal while attempting to eliminate another.

The object of our program is to obtain a cow and a bull known to be free from hairless$_1$. Because a large number of offspring can be secured in a short time (one or two years), proving


Part
Test matings and breeding program
1
2
3
I
II
III
If a hairless, calf is produced, cow A is discarded or used as a tester
If 4 normal and no hairless, calves are produced, cow A is advanced to Part 2.
This mating must produce one but preferably two females. Cow A is then returned permanently to Part 1 for further testing
This mating until enough produced to continuance
The cows are ferred to Part
continued females are assure of line
then transferred to Part 1 for test.
If number of Hr Hr test cows is limited, genotype of mates may be determined by inbreeding.
Transferred to 3 I to determine genotype
Used in 3 II to continue "purged" line and may be tested later in Part 1
If the test of cow A is not complete at this time, bulls may be tested in 3 I and heifers in Part 1. If cow A proves Hr Hr, all animals in 3 II and 3 III are Hr Hr. If cow A proves Hr hr, another cow will be used to establish the purged line.

A GENETIC "LETHAL ASSAY"

Figure 15

Outline of the program for eliminating the hairless defect from the female line. Based partly on an "*ex post facto* progeny test," this scheme makes possible continuance of breeding operations *while the test is in progress.*

the genotype of a bull is relatively simple. It may be done by mating him to 20 of his own daughters; by breeding him to 20 daughters of a bull known to be heterozygous; or by mating him to known heterozygotes. The occurrence or non-occurrence of defective offspring proves with a high degree of probability whether or not he is a carrier. Our cooperative arrangement with dairymen has made it possible for us to assay bulls by all three methods.

Obviously, however, the proving of the cow is a much more difficult problem. We have therefore adopted the plan outlined in Figure 15 in which all cows (designated as A) are bred to a heterozygous test bull (B). When a cow produces one hairless$_1$ calf her genotype is established, and she is then used as a tester for proving unknown bulls. If one of these cows produces four normal and no hairless calves from the test mating with bull B, she has good possibilities of being homozygous normal ($Hr_1\ Hr_1$). The cow (A) is then bred to a homozygous normal ($Hr_1\ Hr_1$) bull designated as C until at least one, but preferably two, heifers are produced. Cow A is then again mated to test bull B as long as she is productive in order to test her further for the hairless gene.

According to Wriedt's standard, cow A should produce at least ten normal calves sired by a test bull (B) before she can be considered homozygous normal ($Hr_1\ Hr_1$). In consideration of the statistical probabilities we are using a higher number of test offspring for both cows and bulls. The complete proving of cow A will be accomplished by testing an adequate number of her descendants sired by the homozygous bull (C). The actual number to be tested will depend upon the number of calves cow A produced from the test mating with bull B and upon the generation in which her descendants are tested.

If a foundation cow (A) proves heterozygous ($Hr_1\ hr_1$), the line produced in Part 3-III (Figure 15) will be discarded. When a foundation cow (A) proves to be homozygous normal ($Hr_1\ Hr_1$), all the animals produced in parts 3-II and 3-III will be homozygous normal. It is hoped that more than one purged cow family may be established. The purging program outlined, being flexible, can be modified to meet any contingencies that may arise.

The program has proceeded only as far as part 1 (Figure 15). Seven cows are in this part of the test, and each has produced from one to four calves sired by the test bull (B). Other females will be added to this group as they reach sexual maturity. Though the method herein described is based on well-known genetic principles, its application to dairy cattle is an experiment and is therefore not recommended for use by the breeder. We are however, employing a second procedure in another family of Jerseys. It requires the use of a continuous succession of herd sires, each of which has been

shown to be free from recessive lethals. Although theoretically, at least, this would never accomplish a complete purging, the number of animals carrying hidden defects would be reduced with each succeeding generation. It constitutes a practical and feasible method by which the constructive breeder may prevent the appearance of lethal defects and at the same time reduce the number of carriers in the herd.

Summary

A recessive, sub-lethal epithelial defect is reported for the first time in Jersey cattle.

The defect was uncovered in the course of an inbreeding experiment.

The description shows the defect to be identical with the one reported by Hadley in Holsteins.

It is suggested that the gene responsible for the defect reported by Hadley be designated as hairless$_1$ (hr_1) and the one described by Mohr and Wriedt as hairless$_2$ (hr_2).

A breeding program which has been in operation for several years and which is designed to eliminate a recessive lethal defect in a family of Jerseys is outlined. The specific defect is hairless$_1$. The essential features of the program may be used for the elimination of any autosomal recessive lethal in cattle.

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5. Mohr, Otto L., and Chr. Wriedt, 1928. Hairless, a new recessive lethal in cattle. *Jour. Genetics*, 19: 315-336.

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Breeding Rust Resistant Mints

The third volume of the *Bulletin of Medical and Technical Plants* (Sympheropol, 1935) is devoted to the peppermint industry in Southern Russia. V. I. Zergovsky discusses rust of peppermint (*puccinia menthae*) and the means of its control. Hybrids between *M. piperica* and *M. crispa* are reported (the latter species being resistant), which are very resistant to rust and yield an oil of satisfactory quality. The statement is made that pubescent forms show a higher immunity to rust than do forms lacking hair on leaves and stems.

R. C.

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TWO ERRORS IN AUGUST *JOURNAL*

Two errors of omission occurred in the August Journal — one accidental and one unavoidable.

The book reviewed by Dr. E. M. East on pages 303-4 of the August issue was: Snyder, L. H., *The Principles of Heredity*: pp. XIII-385. Illustrations 153. Boston, D. C. Heath Company, 1935.

The other error was occasioned by not being able to learn in time who made the excellent portraits of Dr. de Vries used as the Frontispiece and as Figure 1. The photograph which appears as Figure 1 has been traced to Dr. M. S. Markle of Earlham College, to whom we are much indebted for *a posteriori* permission to use the picture. The authorship of the very fine Frontispiece portrait of Dr. de Vries is still unknown.

A LETHAL GENE IN JERSEY CATTLE

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IT has been proved that in a number of species both of plants and animals, factors of heredity may occur which, when found in double quantity in an individual, limit the survival of that individual. Some of these factors may cause death as early as the embryonic stage, but others do not become effective until birth or later. Factors of this nature are called lethal factors.

Dominant lethal factors are obviously incapable of continued existence because they would kill all individuals receiving them, leaving none to transmit the gene. Therefore, those lethal factors that exhibit themselves are necessarily recessive. They exist in a heterozygous individual and exhibit their peculiar effects only when present in a homozygous condition, being inherited from both normal-appearing parents.

Data for Inheritance Studies in Farm Livestock Difficult to Obtain

The amount of data available for the study of inheritance in livestock, especially cattle, is limited. Even before genetics had become a recognized science, many breeders of livestock had found that related animals when mated would often beget weak or malformed offspring. Thus the conclusion was drawn that the mating of related animals, commonly called inbreeding, would give a weaker strain of livestock. Even at present, only a few commercial farms practice inbreeding. Then again many breeders are not financially able to continue inbreeding and to carry a genetic problem to a point where valid conclusions may be obtained, even if they should recognize their ventures in practical breeding as constituting such a problem. The size of the population obtained from one gestation period in cattle is so small that proof is obtainable only after a period of several years. Usually only brief records are kept by breeders and such data as might accidentally be secured are not ordinarily accurate enough for use. Furthermore, the livestock man actively engaged in raising breeding stock will for obvious reasons hesitate to report any defect appearing intermittently in his herd.

Lethal Genes in Cattle

This paper describes a lethal gene observed in Jersey cattle. Several lethal genes have been previously observed in cattle. They are:

Contracture. Hutt[8] studied a case of a lethal gene in Holstein cattle that had been previously mentioned by Mohr. Five calves all full time were produced, but due to muscular contractures they were so abnormal that they died during or shortly after birth. The head was drawn up toward the back and the neck was extremely rigid. The limbs were folded, almost wrapped around the body and extremely rigid. These calves were all sired by the same bull. In three cases the dams were his daughters and in one case, his half sister.

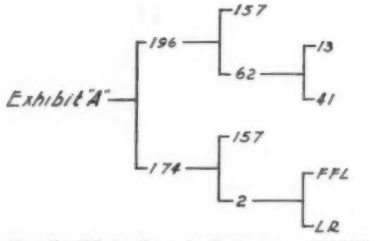
Epithelial. A defect of hair and teeth in Holstein cattle was observed by Cole[2] in 1919, and later redescribed by Hadley and Cole[5] and reviewed by Hadley and Warwick.[6] These calves were of full-term, and of normal size, but were not able to survive longer than a few weeks. They were distinguished by the following characteristics: a defective formation of the skin below the knees and hocks; absence or incomplete development of one or more claws; deformed ears; defect in the integument of the muzzle; and by defective areas in the mucous membranes of the nostrils, tongue, hard pal-

*This study has been made by Carl Wipprecht under the supervision of Prof. Horlacher as a thesis project in the graduate school of the A. & M. College of Texas, and is published in advance of submission of the thesis by permission of the Graduate School.

HAIRLESS CALVES

Figure 16

Two hairless calves designated in the text "Exhibit A" (*A*) and "Exhibit C" (*B*). The pedigree of "Exhibit A" is given at the right. Some of the hairless calves were wry-tailed, as is one above (*B*), but the relationship between the two characters was not determined.



Tattoo No. 157 - Sir Meaves Lad's Emperor 181979

INBREEDING TO BULL 157

Figure 17

All the hairless calves in this herd traced to Bull 157 through both sire and dam. That he was a carrier of the lethal hairless gene seems unquestionable.

ates, and cheeks. Forty-three similarly defective calves were observed. They were in thirteen different herds, all Holstein. A study of the pedigrees of these calves revealed that they all traced to the same foundation stock which was imported from Holland about 1871. Similarly defective calves had been reported from Holland in related herds.

Semi-Hairless. More recently Craft and Blizzard[3] reported a semi-hairless condition in Hereford cattle. The affected animals had only a slight amount of hair on the body with more or less barren areas around the ears and inside the hind legs. The hair present was coarse and wiry. The semi-hairless condition was not lethal but was hereditary and was due to a single recessive gene. The authors were of the opinion that the semi-hairless calves were less likely to survive to maturity than normal calves.

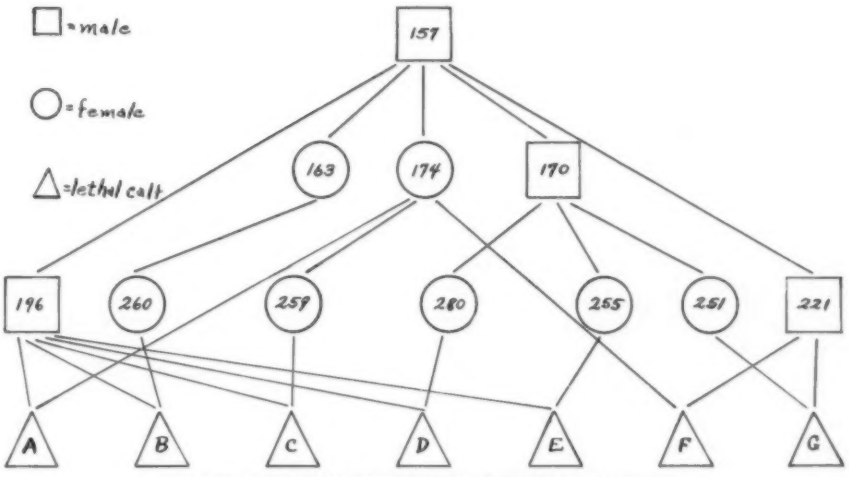
Bulldog Calf. Crew[4] in 1923 and later Seligman, Wilson and Crew,[10] pointed out that in the Dexter breed abnormal calves occur regularly, and that a uniform breed of these cattle is not obtainable. This abnormal calf is called "Bulldog" because of an obvious resemblance to that breed. The skull is vaulted and much rounder than normal, the nose flattened, upper lip split, the lower jaw protruding and the swollen tongue thrust out. The presence of much subcutaneous fat gives the entire body an abnormal development and appearance.

In 1933, Carmichael[1] reported the finding of "Bulldog" calves in African cattle. The Bulldog type calf referred to is aborted during the fourth month of pregnancy.

Telemark. Mohr and Wriedt[9] investigated a similar case of heredity in the Norwegian Telemark cattle. These calves were born at full time, most of them were alive at birth and one lived to be fourteen days old. They had a very markedly shortened head and a short upper jaw. The legs were greatly shortened and so bent that they could not support the animal. Investigation showed that the thyroid gland was abnormal.

All of the abnormal calves in this series, in both lines as regards both sires and dams, were descended from a certain bull, which must therefore have carried the factor for this abnormality. Both cows and bulls that produced abnormal calves were fully normal themselves and could not be singled out from the ordinary Telemark cattle.

Amputated. Wriedt and Mohr[11] re-



COMPOSITE PEDIGREE OF LETHAL CALVES

Figure 18

Pedigrees of the seven hairless calves produced in the Texas herd, showing their double relationship to Bull 157.

ported on thirteen abnormal calves that all traced to one famous bull. Their peculiar defect was that the forelegs terminated at the elbow and the hind legs at the hock joint. The ends of all four legs were bluntly rounded and covered with hairy skin. The head was also quite abnormal. The face was deformed by the downward turning of the upper jaw and by the rudimentary condition of the lower jaw which lacks most of the teeth. This condition is known as Amputated.

Shortspine. Hutt[7] reports that Mohr and Wriedt also found in the Norwegian Mountain cattle an abnormality due to a greatly shortened spinal column. Eleven calves of this type were observed, all tracing to a single sire. The head, teeth, limbs, and hoof were entirely normal but the whole vertebral column was shortened. In such cases the affected calves are born at full time, but if not stillborn, they die almost immediately, death being due to suffocation during parturition.

A Lethal Gene in Jersey Cattle

On May 2, 1933, one of the men working with a Jersey herd that was under the senior author's observation, reported that cow No. 174 had produced a hairless calf, and that it was dead. The authors made an investigation and recognized the abnormal physical condition of the dead calf to be other than that due to what is commonly called abortion which is the premature expulsion of the fetus from a dam affected with Bang's disease. In the latter case the fetus usually appears physically normal if the age of the fetus is taken into account. The dead calf produced by cow No. 174 in 1933 is designated throughout this paper as "Exhibit A" and is shown in Figure 16*A*.

A study of the pedigree of "Exhibit A," given as Figure 17, shows that both the sire and dam trace to the common ancestor Tattoo No. 157, St. Mawes Lad's Emperor 181979, a registered Jersey bull.

It was recognized that the abnormality may have been produced as the result of the action of a lethal gene. Matings were made to determine whether or not the defect was inherited and what animals carried the gene.

Subsequently, six other abnormal calves of this general type have been born on the same farm.

These vary from the normal by having a greatly shortened lower jaw that either lacks teeth or has undeveloped dentition; eyes sunken, with an unbroken hairless skin or membrane over them and the sockets; greatly shortened and abnormal ears lying against and continuous with the flesh covering the head, so that it appears as though the ears had developed under the skin; large hairless areas over the body, with no hair or at least only small spots of hair below the knees and hocks; incompletely developed hoofs; and in some cases, a wry or a modified wry tail. See Figure 16*B*.

The skin of the hairless area is thin, highly congested, red, and slick, and leaves the impression that the upper layers of the skin have a tendency to peel off.

The herd in which this abnormality appeared was T. B. accredited. It had been tested for Bang's disease at regular intervals of about two years and was always found free. Since May, 1933, it has been under state and federal supervision for the eradication of Bang's disease and is now an Accredited Herd, and has not had a single reactor. It is a registered Jersey herd, and the numbers here given are the herd tattoo numbers. Below* we give the details regarding relationship of animals used in matings in this herd.

A summary of all the data gives twenty-nine calves by half brother-sister matings, 27 normal: 2 hairless lethal; and twenty-seven calves sired by sons of No. 157 and from grand-daughters of No. 157, 22 normal: 5 hairless lethal. See Table III.†

The total is 49 normal; 7 hairless

*Twenty-two matings were made to the sire of "Exhibit A," bull No. 196. Six of these were to unrelated cows and their calves were all normal. The other sixteen matings were to cows related to No. 196 through his sire, No. 157. From these matings, as given in Table I four more lethal hairless calves resulted. These are indicated in the table as Exhibit B, Exhibit C, Exhibit D, and Exhibit E respectively. In addition one mating ended with an early abortion of which the fetus was not located. Normal living calves were produced from the other ten matings.

Six sons of the bull No. 157 were used in the herd. They are designated as No. 196, No. 147, No. 210, No. 170, No. 216, and No. 221 respectively. They were used on unrelated cows as well as on animals of a common relation through No. 157. From the unrelated cows 73 calves, all normal, were produced.

Bull No. 147 was used for only a short while in this herd. He sired only four calves. They were from unrelated cows and were all normal.

Bull No. 210 sired only three calves from related cows. They were all normal.

Bull No. 170 was used extensively. He sired nineteen calves from his paternal half sisters, six from daughters of his paternal half brothers and one from his own daughter. All twenty-six of these were normal calves, but three of his daughters from unrelated cows when mated to paternal half brothers of their sire produced abnormal, hairless calves, Exhibit D, Exhibit E, and Exhibit G.

Bull No. 216 was mated with two paternal half sisters and six daughters of paternal half brothers. One of the matings to a half sister resulted in an early abortion while the balance produced normal calves.

Bull No. 221 was mated with four paternal half sisters and the result was three normal calves and one hairless lethal calf, Exhibit F. In addition he was mated with five daughters of half brothers. Only one of these has calved and it produced a hairless lethal calf, Exhibit G.

Table II summarizes the types of matings and the resulting progeny of each son of No. 157 used on cows which were descendants of No. 157.

†In working out the ratio, let "*H*" represent normal hair and "*h*" hairlessness. The progeny of the bull No. 157, from matings with homozygous normal cows, would be:

H H and *H h*

both male and female

When these were mated at random the expected would be:

	H	H	H	h
H	H H	H H	H H	H h
H	H H	H H	H H	H h
H	H H	H H	H H	H h
h	H h	H h	H h	h h

This gives on the average 9 normal: 6 normal appearing but heterozygous: 1 hairless calf, or a ratio of 15:1. The actual result was 27 normals: 2 hairless and is very close to the expected ratio.

When a bull which is known to be heterozygous is mated at random with the daughters of heterozygous bulls from homozygous cows the expected would be:

	H	H	H	h
H	H H	H H	H H	H h
h	H h	H h	H h	h h

This gives an average distribution of 3 homozygous normal: 4 normal appearing but heterozygous: 1 hairless calf, or a ratio of 7:1. The actual result from matings of this type was 39:7 normal hairless calves.

lethal calves. This is within the expected ratio of an inherited character due a simple recessive gene.

When both the sons and daughters of a heterozygous animal which has been mated with homozygous normal animals, are mated at random *inter se* the expectation is a ratio of 15 normal to 1 abnormal. When all of the daughters of a heterozygous sire are mated to heterozygous sons of that sire the expected ratio is 7 normal to 1 abnormal. If the progeny of the bulls No. 210 and No. 216 which were animals that did not prove heterozygous and which sired only a small number of calves, are omitted there is a total of 39 normal and 7 hairless lethal calves. This is very close to the expected 7:1 ratio.

The exact nature of the defect of the skin was not determined as attempts at microscopic study were not successful. Detailed descriptions of the hairless calves is given below.*

The sires and dams of these hairless calves presented no appearance that would distinguish them from normal animals except possibly slightly shortened ears. Bulls No. 157 and No. 221 had ears that had a slightly frost bitten appearance.

Breeding History of the Dams of Hairless Calves

It also appears that cow No. 174 is the dam of two of the hairless calves, sired by different bulls. She is also the maternal grandam of another defective calf, her daughter having been sired by an unrelated bull.

The breeding history of No. 174 shows that she has produced five calves, three of which appeared normal and two abnormal. One of the former proved genotypically heterozygous for the hairless factor. This is in line with what would be expected when the condition is caused by a single gene that is a simple recessive.

Cow No. 260, which is the dam of Exhibit *B*, is a granddaughter of bull No. 157 through cow No. 163. Cow 163 calved from four matings, as shown below:

Bull	170	13	13	196
Cow 163	normal twins	260 heterozygous	normal	normal

Cow No. 260 produced but one calf which is shown as Exhibit *B*. Cow No. 251 had two calves, 1 normal and 1 hairless lethal. Both calves were by bulls that were proved to be heterozygous.

The remaining three dams had only

***History and Description of the Variations of Hairless Calves**

Exhibit A. Dropped May 2, 1933. Length of gestation, 248 days. Considered normal as to size. Tail normal; skin abnormalities typical. Sex: male.

Exhibit B. Dropped March 6, 1934. Dam, pasture bred. Gestation period estimated from time bull turned in pasture to be about 165 days. Sex: female.

Exhibit C. Dropped June 4, 1934. Gestation period 257 days. This calf was normal in size, but exhibited some evidence of a shortened wry tail. There was no indication of scrotum, teats, or vulva. It was supposedly a female, as mammary tissue was present under the skin.

Exhibt D. Dropped August 13, 1934. Gestation period estimated 200 days. Dam, pasture bred between December 24, 1933, and March 6, 1934. Owing to a posterior presentation this calf had to be taken. The tail was very much shortened, crooked and wry. No scrotum, vulva, or teats were present.

Exhibit E. Dropped September 10, 1934. Dam, pasture bred. Gestation period about 215 days. In this exhibit the ears were not as completely grown back as in the others. The tail was about two-thirds normal length with a kink near the end. Sex: male.

Exhibit F. Dropped February 15, 1935. Gestation period 264 days. The dam of this exhibit is also the dam of Exhibit A. The cow was with the regular herd but failed to come to the barns on the afternoon of Feb. 15th, 1935. The morning of Feb. 16th, she was located in the pasture with the dead fetus by her side. Prowlers had partly destroyed the fetus so that the sex could not be determined. The major portions of the body remained intact and therefore it was possible to determine that the case was typical.

Exhibit G. Dropped March 8, 1935. Gestation period 142 days. This cow had just completed a Register of Merit test and was being milked only in the morning. When the fetus was located all but the hide, head and one hind leg had been destroyed. These members showed typical abnormalities.

A composite pedigree of all of the hairless lethal calves is given in Figure 18. A study of all of the pedigrees of these hairless calves shows that the registered Jersey bull tattooed No. 157, St. Mawes Lad's Emperor 181979, is the only animal that is common on both sides.

one calf each. Shown as Exhibit *C*, Exhibit *D*, and Exhibit *E*.

Number of Calves Necessary to Prove A Bull to be Heterozygous

The statement had been made several times in the literature on lethal genes that twenty sire × daughter matings are sufficient to prove whether or not the sire is heterozygous for a lethal gene.

Since the expected ratio from such matings, in case the sire carries the lethal gene, is 7 normal: 1 lethal, at least two homozygous lethal combinations should result from matings of this type.

As given in this paper, the bull No. 170 was used in twenty matings with the daughters of heterozygous bulls and produced only normal calves from these matings. The cows were not his own daughters, but all were daughters of heterozygous bulls, nineteen being daughters of No. 157 and one his own daughter.

This bull, No. 170, was later proved to be heterozygous for the hairless lethal gene, as three of his daughters from unrelated cows produced hairless lethal calves when mated with other bulls which had previously been proved to be heterozygous.

Summary

An inherited lethal condition, which is called hairless, exists in the Jersey breed of cattle.

This hairless lethal defect appears to be caused by a single gene which is a simple recessive.

There is no definite time of expulsion of the hairless fetus by the various dams.

The hairless defect appears to be closely associated with the condition known as wry tail. The latter is common but has received little study.

This hairless gene is not sex linked as both male and female hairless calves have been born.

Twenty matings of a heterozygous bull with daughters of bulls known to be heterozygous for the hairless gene were not sufficient to prove the heterozygosity of one bull.

Table I. Matings of the Bull No. 196 to Related Cows.

Paternal Half-sisters			Daughters of half brothers (same sire)				Other granddaughters of No. 157.	
			No. 147		No. 170			
Cow No.	Resulting progeny		Cow No.	Resulting progeny	Cow No.	Resulting progeny	Cow No.	Resulting progeny
174	EXHIBIT A		206	Normal	227	Normal		
174	Normal				233	Normal		
196	Normal				242	Normal		
163	Normal				254	Aborted		
					265	Normal	280	EXHIBIT C
					277	Normal	280	EXHIBIT B
					256	EXHIBIT E	269	Normal
					280	EXHIBIT D		
TOTAL	Normal	3		1		5		1
	Hairless	1		0		2		2

Table II. Type of matings and the resulting progeny for each son of No. 157 used in this herd on cows which were descended from No. 157.

Son of No. 157	Type of mating		Total	Resulting progeny	
	Brother-sister	Granddaughter of No. 157		Normal	Hairless
No. 196	4	11	15	10	5
No. 170	19	7	26	24	0
No. 210	1	2	3	3	0
No. 216	1	6	7	7	0
No. 221	4	1	5	3	2
Total	29	27	56	49	7

Table III. Summary of the matings of related animals descended from the bull No. 157.

	Mated to			Calves produced	
	Daughters of No. 157	Granddaughters of No. 157			
		Paternal	Maternal	Normal	Hairless
Sons of 157	29	25	2	27	2
				22	3
				0	2
Total				49	7

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THE EMERGENCE OF NOVELTY

A Review of Lloyd Morgan's "Emergent" Theory of Evolution

THE phrase "emergent evolution" has entered much into discussions of organic evolution since the appearance of Lloyd Morgan's book of this title. In the book here under review,* Morgan attempts to clarify the conception, to develop its applications especially to mental evolution and to bring out its philosophical implications.

Definitions

As the author notes, the words emergent and emergence are somewhat ambiguous. Webster's Dictionary defines emergent as follows:

1. Rising or emerging out of a fluid or anything that covers or conceals.
2. Suddenly appearing, arising unexpectedly, calling for prompt action, urgent.
3. Arising as a natural or logical consequence or outcome.
4. Provided for use in an emergency.

We may dismiss at once the first literal meaning and the fourth. The second, omitting the final phrase, is closest to Morgan's usage, while the third, if interpreted as "arising expectedly" is the antithesis. The following quotation (p. 59) illustrates his emphasis on both abruptness and unpredictability.

> Are there at certain salient stages of organismic advance new modes of substantial relatedness, the advent of which could not have been predicted on the basis of full and adequate knowledge of all that had thus far been reached at any or all of the foregoing stages? The emergent hypothesis is that there has been and still is supervenient novelty in the salient steps of organismic advance and that such novelty is unpredictable prior to its advent.

Morgan derives his usage of emergent from a suggestion made by G. H. Lewes in 1875 in which he contrasted the unpredictable "emergent" properties of chemical compounds with the merely additive or "resultant" properties of mechanical mixtures.

The properties of chemical compounds illustrate both the suddenness of appearance and the unexpectedness given above in the second definition of emergent. Discontinuity and unexpectedness often go together. There are cases, however, in which there seems rather to be a gradual development of unpredictable properties, the departure from the direct line of expectation being like that of a curve from its tangent. Organic evolution, in many cases at least, seems to have been of this type. In yet other cases there is abrupt change of properties when conditions attain a certain threshold but the new properties can be adequately accounted for. Should either or both of these latter alternatives be considered under the head of emergence? There is a possibility of confusion here which the author does not wholly clear up. He cites the emergence of crystals from saturated solutions and the changes of state between gas, liquid and solid as examples of "emergence." Under the physical theory, molecular attraction and the dispersive effects of molecular kinetic energy are present in all states. The abrupt changes in the properties of molecular aggregates at certain thresholds of temperature and pressure are expected under the theory, and would seem rather to be "resultants" than "emergents", unless abruptness by itself is a sufficient criterion for the latter.

The author does distinguish between the "primary novelty" of a first occurrence and the "secondary novelty" of a recurrent event. If there was ever a time in the history of the universe when hydrogen and oxygen had never combined, the first water would exhibit primary novelty in its properties. At present, the properties of water can not (perhaps) be accounted for from those of hydrogen and oxygen, although the results of combining these are, of course, predictable from past experience: there is merely secondary novelty.

*Morgan, C. Lloyd. The Emergence of Novelty. Williams & Norgate. London. 1933.

A more fundamental distinction would seem to be between the type of unaccountability of the repeatable aspect of events, whether at first or later occurrence and that of the unique, unrepeatable aspect of individual events. The state of the universe presumably never wholly recurs. Its history is a cumulative process. The interrelatedness of things is such that it is improbable that even the simplest event is ever exactly repeated. Practically, however, such events may be sufficiently similar to speak of recurrence. On the other hand, more complex cases such as the activities of a living organism or the events of human history present patterns which are much less repeatable. Here we have primary novelty in a more rigorous sense. Organic evolution is a history and no doubt each step involves primary novelty in this sense to an important degree. We will come back later to the question of the appropriateness of using the same term, emergence, in relation to secondary and primary novelty.

Emergence as a Scientific Hypothesis

The author presents the hypothesis of emergent evolution as a scientific (rather than a metaphysical) hypothesis:

> If we take the world as we find it, there are now "in existence" atoms, molecules, crystals; gases, liquids, solids; matter, life, mind. Evolution offers an interpretation of their natural genesis expressed in a comprehensive generalization. Emergent evolution, or advance through new modes of organization to further novelty in organization is a supplementary hypothesis recently placed on trial at the bar of scientific inquiry.

He distinguishes science — "all empirical inquiry the aim of which is to render an exact account of actual processes, physical and mental, calling to aid all that may be contributory to that end —logic and mathematics for example," from metaphysics—"an inquiry the aim of which is to account for that of which science thus seeks to render an account."

A digression here is convenient. The above quotation suggests that mind is ultimately emergent from matter. The author later questions this possibility and in this the reviewer decidedly concurs. Individual consciousness is the direct experience of a very small aspect of reality. Matter is a name applied to aspects of reality whose existence and nature are deduced only indirectly from the interactions involved in sensation but whose substantial reality, as well as one can judge, is probably not essentially different in kind from that of the observing consciousness. The direct experience would seem necessarily to be primary.

Morgan makes much of a tripartite division of the field of human inquiry: *A* (activity) metaphysical inquiry, *B* (body) empirical physical inquiry (including biology), *C* (consciousness) empirical study of mind. Emergent evolution he wishes to be considered as a hypothesis in the *B* and *C* fields rather than in *A*. As noted, other authors have followed him in this, treating emergence as a scientific hypothesis coordinate with such mechanisms as natural selection in the scientific explanation of organic evolution.

But is this a legitimate procedure? The questions of what are meant by science and scientific hypothesis are at issue. Science is primarily concerned with discovering and describing such order as there is in a world in which it is probable that every individual event has unique aspects. As Karl Pearson brought out many years ago in his *Grammar of Science*, science is always essentially statistical, being always based on classifications which of necessity throw more or less diverse things into common categories. The uniqueness of individual events to some extent escapes even purely descriptive science and indeed escapes language, since words represent statistical categories.

A scientific hypothesis is one that attempts to describe a certain order. The orderliness described may be of different degrees. The laws of mechanics describe the behavior of massive bodies with great precision. The order described by the Mendelian hypothesis is often poorly exhibited in small families but is well exhibited where there are large numbers. Even the Heisenberg indeterminacy principle has a quantitative aspect in setting rather definite

limits to the possibility of simultaneous determination of position and velocity. The hypothesis of emergence, on the other hand, has no such aspect and thus seems wholly negative on the scientific side. As a working hypothesis, its effect is rather to discourage the search for such order as may exist than to further it.

In the cases which Morgan describes as emergence of secondary (or recurrent) novelty, there is a statistical regularity which will doubtless continue to challenge scientists for explanations of the scientific sort. The chemists have not been content to follow Lewes and account for the properties of molecules as "emergents." The organic chemists synthesize innumerable new compounds with properties predicted, to a considerable extent, in advance. The inorganic chemists by no means dispair of being able to account for the differences of such substances as CO_2 and SiO_2 in terms of a theory of intramolecular and intratomic relations. The physiologist will doubtless continue to search for such self-regulatory mechanisms as L. J. Henderson has described in the constitution of blood. Similarly the geneticist can not be satisfied by merely calling the nonadditive or epistatic effects of genes "emergents" as Morgan suggests (p. 123). He hopes to find out why the effects are as they are in terms of the physiology of gene products. The case is similar if even more difficult with mutation. Embryologists will doubtless long find it convenient to interpret development in terms of broad organismic principles, but the goal of scientific research is again the analysis of all classifiable phenomena in terms of ultimate factors—here genes and external environment. In the whole field of Morgan's "recurrent novelty," the task of science would seem to be the replacement of "emergent" by "resultant" as the appropriate adjective.

With respect to apparent "primary novelty" science can proceed some distance by ever finer classifications but there are various things which indicate that there is a limit. In the physical sciences, the indeterminacy principle seems to define such a limit. At a much higher organismic level is the fact that in the mental field, the consciousness of freedom of choice makes such a limit a matter of direct experience.

Choice does not mean complete lack of order. It is compatible with any degree of statistical regularity. It is possible that events are determined, not merely occasionally and to a limited extent by choice, but completely, choice being of the very essence of change; but that events depend in general on the interaction of so many entities each with some degree of consistency of behavior, that there may be a very high degree of predictability and hence of apparent determinacy. Such a view admits what may be called "emergence" as always present and indeed the sole factor in the movement of events. But this is in Morgan's *A* field of inquiry not his *B* or *C* fields which are concerned with describing such statistical regularity as is in events. As a scientific hypothesis, the principle of emergence seems at best a sort of nonquantitative Heisenberg principle, recording the probability that scientific analysis can never be complete.

It is interesting that this scientific indeterminacy seems to be much greater in connection with living organisms than with non-living things. As I have stated elsewhere "an organism appears to be a system linked up in such a way through chains of trigger mechanisms, that a high degree of freedom of behavior as a whole merely requires departures from regularity among the ultimate parts of the order of infinitesimals raised to powers as high as the length of the above chains." It is not so much that unpredictable behavior of the organism is determined by amplification of unpredictable actions at the quantum level as the reverse. Direct experience indicates that the organism behaves as a unit. Apparently the mental field of the whole represents such a fusion of those of the parts that acts of choice in the former "determine" the behavior of the latter; since the former is scientifically indeterminate, the latter remains so.

Application to Organic Evolution

So far we have said little of the application of the emergent hypothesis to organic evolution. Morgan's books go very little into the physical side of evolution. His most concrete applications are to mental evolution, to which a large part of the present book is devoted. While this treatment is of great interest, I shall not here attempt to review it. The psychic interpretation of animal behavior resting necessarily on introspective analysis of a human mind is hardly capable of scientific treatment as this is understood in other fields. Morgan's discussion here does not help much in indicating what application, if any, can be made of the emergent hypothesis in the scientific analysis of organic evolution.

A question of interest is the relation of emergence to mutation in de Vries' sense. The abruptness of mutation seems to accord with Morgan's conception of emergence. Most of de Vries' mutations, however, have turned out to be recurrent chromosome aberrations. In so far as speciation depends on this factor, the changes are matters of secondary novelty in Morgan's sense and so, according to our analysis, ones in which the application of emergence as a scientific hypothesis is especially questionable.

Speciation in general probably involves changes in thousands of gene frequencies in indefinitely extended multiple allelic series. These occur under the influence of a complex and unique environmental history which includes those intangible conditions described as chance. Moreover among the factors of evolution are the choices of finite, and at critical periods, of relatively small numbers of individuals. It is to be expected that evolution will in general involve primary (non-recurrent) novelty at each step. Prediction of the course of evolution of any species is out of the question in any but the broadest terms. There may, however, be considerable accountability from step to step. If the term emergent is to be used, it should rather be in the sense of the third definition "arising as a natural or logical consequence or outcome," unpredictability being indicated by the use of the indefinite article, than in the second sense, involving "suddenly appearing." The type of scientific indeterminacy indicated here has, of course, been understood by biologists since the time of Darwin to be implied by the word evolution itself, making the adjective emergent rather superfluous. Morgan, however, seems to mean more than this.

The relatively abrupt changes in the direction of evolution which have frequently occurred when an organ evolved for one purpose has turned out to be adaptable to another, opening up, perhaps, a wholly new way of life, represent a type of evolutionary change which comes closer to Morgan's usage of emergent. The emergence of the tube feet of most echinoderms from tentacles, of the jaws of true fishes from the first branchial arch, of legs from fins, of feathers from scales, etc., are examples. In these cases the change of direction is no doubt sufficiently unpredictable, but having occurred is not wholly unaccountable. From the standpoint of description, it may be convenient to use emergent as a term to contrast with orthogenetic. But it is not clear that the hypothesis of emergence adds anything to the scientific explanation.

The most remarkable "emergence" in relatively recent geologic time is probably the appearance of man. The difference between the mental capacity and the mode of life of man and the closest animals is so great that some of the earlier biologists felt it necessary to put man in a separate order, or even class, phylum or kingdom. Yet the family Hominidae has left no clear evidence of existence before the Pleistocene or late Pliocene and according to most paleontologists could hardly have diverged from the anthropoid stock earlier than the Miocene, making it nearly if not quite the most recent of the recognized families of mammals. As far as physical traits are concerned

there is no unprecedented degree of change. The human hand was essentially an early primate acquisition and other primates than man wield objects as tools. The trend toward increased size of the brain (and increased intelligence) was well under way in this order. The assumption of a fully erect posture with adaptive modification of the foot and other parts of the body are more peculiarly human but offer no unusual problem. According to many authors, the essential distinction of man from animal is in none of these physical traits but in possessing, and depending on a developing tradition. A new, largely independent and relatively very rapid, cumulative process, the evolution of ideas seems to have "emerged" rather abruptly at a certain point in the hominid line, making possible an unprecedented change in mode of life. But must we postulate a wholly mysterious emergent as the explanation? The change again does not seem an unaccountable one, although we are here in Morgan's *C* field with all its difficulties of scientific explanation. There is an analogy with the abrupt change of state at certain thresholds in physical systems. The attainment of a certain threshold in the gradual evolution of intelligence has as a natural enough consequence the development of symbolic speech from the emotional cries of an animal. This naturally initiates the cumulative development of ideas. The term emergence may be applied but again rather as a descriptive term than as a scientific hypothesis contributing to the explanation.

The greatest of all "emergencies" in Morgan's *B* field is doubtless that of life from the non-living. There is certainly not much of scientific value which can be said at present on this problem. There are indications, however, in the properties of genes and viruses, the smallest and presumably simplest things with the essential property of life, that the transition even here may not prove as abrupt and unaccountable as once appeared.

Summary

The Emergence of Novelty, as with Lloyd Morgan's other writings contains material which should engage the attention of any one who considers the question of evolution philosophically. From this standpoint the reviewer finds much with which he agrees. It seems probable that there is a unique aspect to every event, which of necessity escapes the statistical net of science and thus that evolution like any other history involves the more or less gradual "emergence" of unpredictable novelty. The emergent hypothesis should not, however, be considered as a scientific hypothesis. It expresses rather a probable but undefined limitation on the possibility of complete scientific treatment. It seems questionable whether it should be applied at all to the recurrent properties of systems (results of chemical combinations, of gene combination, course of ontogeny, etc.) however unaccountable these may be from the properties of the components in the present state of science.

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ALLEGED ABNORMAL SEX RATIOS IN BOLIVIA

THE publication in 1931 of a statement regarding an astonishing departure from a 1:1 sex ratio, observed among the Indians of the Bolivian Chaco has elicited an inquiry regarding the accuracy of these observations. The statement in question appears in *Green Hell* by Julian Duguid. This is an account of an expedition which crossed a little known region of the Bolivian Chaco, following the track of the Spanish missionaries and explorers of the fifteenth century. Regarding sex ratios Mr. Duguid has this to say:

In 1768 Santa Corazon, which I shall take as an example, both because my chronicle has reached that point, and because it is typical, had 2,387 inhabitants. Reading between the lines one can see that they married young,

lived to a reasonable age, and had numbers of children, almost equally male and female. As there were few widows and widowers, and re-marriage was rare, it is fair to assume that the expectation of life was equal to both sexes.

* * * * *

Santa Corazon today has exactly sixty inhabitants, poor, lazy and woman-ridden. The men, for the most part, are weedy, inconsequent little creatures, muddle-headed from *chicha*, lacking that steel spring that makes a man realize that work is worth doing for its own sake. Yet the church has 400 cattle.

The present birth-rate in Chiquitos is an amazing affair. Not only in Santa Corazon but in Santa Cruz itself, there are nine girls to every one boy. What is the reason? Asuncion was in a like state seventy years ago, but Paraguay had just lost her manhood in a bloody war. Chiquitos is at peace, and has been since the arrival of the Jesuits. Is the province so inert and lifeless that girls are produced because their gentler natures are more in keeping with the times? Is there so little manliness in man that Providence, tiring of the game, has adopted this method of ending it? Urrio and I talked it out on many occasions, and we came to the following conclusion: It is a physiological commonplace that boys predominate after the carnage of a war, but there are at least two possible reasons for it. Does the expectant mother's mind become so agonized with anxiety for her man that by very suggestion the sex of the child is determined? Or is it that the world has gone mad for a space, and man becomes in truth the dominant and masterful factor that he seldom is in peace time? At first sight there seems to be little difference between these theories, nor is there in time of war. But apply the ideas to the somnolent province of Chiquitos and the answer is otherwise. There is neither anxiety nor agony, now is there any strong feeling of any kind. Man is entirely useless and would have long ago died out were he not slightly necessary for the procreation of children. As a potent and dominating factor he is dead. Wherefore it seemed to us that he had so far failed to impress his personality on the women that they had given up heeding him, and in consequence it was in the nature of an accident when a boy was born.

The humorous side of the matter is the attitude of the men. They sit in the doorways of their mud and plaster houses, or lounge about the square and peevishly command their women to set about the business of the day. Theirs is the attitude of a conquering army, returning hot-handed with the loot of war, and too puffed-up to be bothered with the matters of the field. With a little wave of their hands they indicate the maize patch and the banana grove, and point grandly to the water-pots. In a warrior, bursting with ardour, the sentiment would be sublime; in an under-sized Indian with drink-bleared eyes it is apt to be ridiculous.

And the women take it in good part. They are not the least bit humble or subservient. They do not fear the wrath of their lords and masters. Why should they when physical labour has made them actually the stronger sex? They seem to accept the situation as a kind of grave joke, and treat their men with a good-humoured toleration which is most entertaining to watch. The men themselves fail lamentably to appreciate the matter, and the female children toddle about in the dust, a veritable banner of shame which their fathers are too dense to see. There, if anywhere in the world, man is a kept creature.

While we cannot accept Mr. Duguid's fanciful explanations for deviations from the normal sex-ratio, the *fact* of such remarkable deviation from equal numbers would be a matter of considerable interest. Some years ago a note in the JOURNAL called attention to an abnormal sex ratio in another part of South America.* In this instance the deviation was in the other direction—males predominating, but not to any such extreme extent. Duguid's observations and those of Dr. Pittier might be taken as an indication of some fundamental instability in the sex-determining mechanism in South American Indians. Such a possibility gave an added interest to confirming Mr. Duguid's observations.

Through the kind offices of a member of the American Genetic Association in Chile we have been able to obtain some direct information regarding sex ratios at birth in this region, though not from the same towns. Since Mr. Duguid implies that the phenomenon is one of rather wide occurrence, these data still are germane to the matter in question. Our information is from Dr. D. S. Bullock of the El Vergel School of Agriculture at Angol, Chile, to whom we are greatly indebted. He writes as follows:

Your letter of July 16, 1934, came duly to hand and I have been doing what I could to get a satisfactory answer.

The fact is that I am nearly 2,000 miles

*PITTIER, HENRY. A Change in Sex-Ratio. *The Journal of Heredity* VII: 406-411. 1917.

from the towns of Santa Corazon and Santa Cruz so I have been obliged to depend entirely on writing to get the information.

Fortunately I knew two missionaries working in Bolivia and wrote to them for any data which they might be able to obtain concerning the birth rate in the regions mentioned.

(1) I wrote particularly for official figures if these were obtainable, The only figures which I was able to get are from the "Paroquia San Andres" in the Province of Cordillera, Department of Santa Cruz for the year 1932, which may be summarized as follows:

Males	201
Females	197
Total Births	398

On separate sheet I give copy of this report in detail.

It is true that this is not the exact region referred to in the book *Green Hell*, but the population is practically the same type of Indian and conditions are very similar. The actual ratio between the sexes would probably not be much different in the two places.

(2) A colonel in the Bolivian army who had spent most of his life in that region of Bolivia was asked concerning the statement "the birth ratio is nine girls to one boy." He made more or less the following answer,—"There are many more women than men but this is due to the fact that the men have been recruited for work in the rubber forests. The birth rate is probably about equal."

(3) I have before me a letter from a missionary in which he says "I live in Izozo, Province of Cordilleras. So far as births are concerned *here* the ratio is most certainly *not* 9 girls to 1 boy. It is out of the question. The ratio, I should say would be more or less *equal* with only a *slight* preponderance of girls." (The italics are his.)

This is all the information which I have been able to obtain but sincerely hope that it will be useful to you.

* * * * *

Apparently the important thing is to get the good story even if the facts are slightly at variance with the statements. I suppose one would call it literary license.

It is probable that in the region in question the actual proportion of men to women is even more abnormal now than even when the book was written. Great numbers of men have been taken from this very region as recruits for the Bolivian army. It is not at all impossible that actually now there are nine women to one man in all the region. This is of course an entirely abnormal situation and has nothing to do with the actual births.

Mr. Bullock also forwarded a detailed table showing the monthly birth ratios for 1932. In this there appear to be no significant deviations from equality at any season of the year, and the number of births per month shows little variation.

It would seem unlikely that Duguid deliberately fabricated such a trivial addition to his story, unless it was done with an idea of adding somehow to the "sex appeal" of a not risque narrative. The conclusions he reached are more reasonably to be ascribed to the random variability of small samples. Since Santa Corazon had a total of only sixty inhabitants the "female banner of shame", in the persons of a multitude of girl babies, could not have been very large. In a total population of sixty we would hardly expect more than a dozen children even were the birth rate higher, and the mortality rate lower, than we would expect. On the basis of a 9:1 ratio there could have been only one boy in the entire population of the town. Such a deviation from equality in so small a sample might be due to chance. The conclusions therefore, even if the observations were entirely accurate, would have to be weighted with a very large probable error. If the child population were much larger than this, evidently Duguid's estimate of the total population is seriously in error.

It thus appears that the sex ratio among the Indians of eastern Bolivia is not a matter that the geneticists will have to "explain," at least until more convincing data, showing statistically significant departures from the normal, are available. War and rubber appear to be adequate to account for some deviation from equality. The only statistics we have been able to obtain from this region show no abnormal trends, and we may therefore continue to look with profound suspicion on "psychological sex-determination" brought about by the deplorable state of subserviency of the unfortunate husbands of Santa Corazon, which is so touchingly described.

R. C.

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

ENVIRONMENT AND GROWTH, *by* BARKEV B. SANDERS. Pages, 375, 365 page bibliography. Warwick and York, Inc., Baltimore, 1934.

A monograph on what makes children grow.

OUR HERITAGE AND OTHER ADDRESSES, *by* HERBERT A. BRUCE, Lieutenant-Governor of Ontario. Pages, 392. Price, $2.50. Macmillan Company of Canada Limited, 1934.

Many statesmen and some physicians are skeptical of the importance of human heredity. It is therefore noteworthy that the former Lieutenant Governor of Ontario, a successful physician who turned from healing his patients to attempting to heal the body politic of his native province, should enthusiastically uphold the need for more applied genetics in human affairs.

CHRONICA BOTANICA. Pages 447. Volume I. Leiden, Holland, 1935.

What the botanists of the world are doing and where they are doing it. Being a new form of botanist's address book, world wide in its scope.

SCIENCE AND THE PUBLIC MIND, *by* BENJAMIN C. GRUENBERG. Price, $2.00. McGraw-Hill Book Company, New York, 1935.

Science has pretty much remade the physical world. Can a wider appreciation of the methods of science be useful in solving our social problems? If so, how is this wider appreciation to be "sold" to the great masses of the scientifically unsophisticated? Dr. Gruenberg surveys possibilities.

STUDIES IN THE PSYCHOLOGY OF MUSIC, Volume II. Measurement of Musical Talent, the Eastman Experiment, *by* HAZEL MARTHA STANTON. Pages, 141. Price, $1.00. University of Iowa Studies, 1935.

Foundation research on which some day may be built an understanding of the inheritance of musical talent.

HEREDITY AND THE ASCENT OF MAN, *by* C. C. HURST. Pages, 136. Price, $1.50. The Macmillan Company, Cambridge, England, 1935.

One of the pioneers in genetic research affirms his conviction that man's future is today of his own determining, and that by the application of biological laws he has it in his power, to an extent never hitherto possible, to be master of his own fate.

THE PHILOSOPHY OF A BIOLOGIST, *by* J. S. HALDANE. Pages, 155. Price, $2.50. Oxford University Press, London, England, 1935.

Many people do not realize that there are two biologist Haldanes in England, related rather more closely by blood and in initials than in philosophical outlook. The philosophy of J. ***B.*** S. Haldane would be quite another matter, and we are inclined to paraphrase a popular advertising slogan: "what a whale of a difference a capital 'B' makes!"

BOTANY OF CROP PLANTS, *by* WILFRED W. ROBBINS. Third Edition. Pages, 639, 269 illustrations. Price, $4.00. P. Blakiston's Son & Co., Inc., Philadelphia, first edition 1931.

The three editions in two years indicate that a rather badly neglected field of botanical endeavor is not without interest.

AFTER THREE CENTURIES, *by* ELLSWORTH HUNTINGTON and MARTHA RAGSDALE. A typical New England family. Pages, 274, charts and tables. William and Wilkins Company, Baltimore, 1935.

This volume attempts as objectively as possible to find out what some New England families have done with themselves in these three centuries they have been here.

INHERITANCE OF STATURE THROUGH MATE SELECTION

Pedigrees of Six Families in which Assortative Mating Has Affected Stature

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STATURE is a human characteristic that is easily measurable and so lends itself to investigation. It is a more difficult matter, however, to be in a position to investigate height in families through several generations and to endeavour to evaluate such factors as the influence of nutrition, town or country conditions of life or, most difficult of all, the conscious or subconscious exercise of choice of mates of similar stature. Extreme cases of stature are needed, since there is always the tendency for regression towards the mean or normal in height. For this reason, very tall or very short families have a peculiar interest.

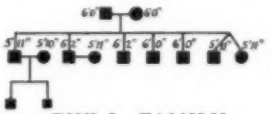
Some thirty families showing inheritance of tall or of short stature have been investigated by us, both in South Africa and more recently in Canada. In most of them there has been admittedly selection of life-partners of much the same height. Some of the more striking of these cases may be described. We wish to thank the families for their coöperation and permission to publish the accounts, and we have respected their objections to photographs being taken.

Inheritance of Tallness

The **L.** *Family* (Figure 19)

The *L.* family are tall Canadians of mixed English, Scotch and French descent. They have been resident in Canada for many years. The founders of the *L.* family were Norman French from near Caen, Normandy, who had intermarried with English people from Hampshire. Three generations of this family are known to us, all being relatively prosperous, well-nourished people, mostly of sturdy farming stock.

The oldest member known to us is a man of 66 years of age who is 6′0″ in height. He is married to a tall, Scotch Canadian, who, like her husband, is 6′0″ in height. Her people originally were Highlanders from Aberdeenshire. They have six sons and a daughter, the F_1 generation known to us. The eldest, a son (5′11″), aged 36, is married to a "big" French woman (5′10″). They have two boys aged 6 and 4, both "big for their age." The second F_1 member (6′2″), a son aged 34, married an Irish Canadian woman (5′11″); they have no family so far. The third F_1 son (6′2″), aged 32, is unmarried. The fourth and fifth sons aged 29 and 28, and both 6′0″ tall, are unmarried. The sixth and seventh F_1's are fraternal twins of opposite sex, aged 26, both 5′11″ in height and unmarried.



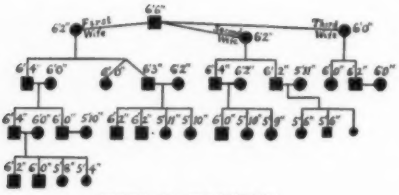
THE L. FAMILY

Figure 19

Tall Canadians of mixed English, Scotch and French descent. The founder and two filial generations are charted. Heights are given except in the case of children who are represented by small squares or circles. In this family and in the following families, the members are well proportioned and well nourished, all being relatively well-to-do.

The members of this family are very proud of their height and one of them had no hesitation in stating that "none of us would dream of marrying little people; we are of Norman blood and proud of our family height."

The seven F_1 members of the family average just over 6′0″ in height. The two younger women who have married into the F_1 generation average 5′10½″. The family are quite conscious of height selection in the marriages made in the present and in the remoter generations of the family.



THE G. FAMILY

Figure 20

Tall Canadians, the descendants of a very tall man who married three times and in each case chose a very tall wife. The offspring of each wife were also very tall and those who married chose tall mates, thus continuing the characteristic into three filial generations already.

Another tall Canadian family, the *G.* family, are the descendants of *J. G.* and his three wives, all of English extraction. Three generations are known to us. They are physically well-built, strong people, in fairly good circumstances.

The founder of the family is stated to have been one of seven sons, all over 6 feet in height. He himself was 6′6″. His three families may be considered separately. By his first wife (6′2″) he had three children, who form part of the F_1 generation. The eldest, a son (6′4″) now 62 years old, is married to a tall British Canadian woman (6′0″). They have two sons, the elder is 6′4″ and the younger is 6′0″. The elder son when he was 18, married a French Canadian woman (6′0″). He is now 38 and his wife 40 years old. They have four offspring, a son (6′2″) 20 years of age; a son aged 18 (6′0″); and two young daughters, 16 and 12, whose height is 5′8″ and 5′4″.

The younger F_2 son is now 32 years of age. He is 6′0″ in height and is married to a French Canadian woman (5′10″). They have no family.

The second of the family of *J.G.* and his first wife is a single woman now 60 years old, and 6′0″ tall. She is twin sister to the third member, a man 6′3″. He is married to a Danish woman (6′2″). They have four children, a son (6′2″) aged 22; a son (6′2″) aged 21; a daughter (5′11″) aged 19; and a daughter (5′10″) aged 17. All are unmarried.

All the descendants of *J.G.'s* first marriage are tall and those who have married have chosen tall mates.

J.G.'s second wife was 6′2″. Their eldest and youngest children, both sons, are living and there were several miscarriages between these two. The elder son (6′4″) now aged 53, married a tall English Canadian (6′2″). They have three children, a son (6′0″) aged 20, unmarried, and two daughters, aged 18 (5′10″) and 16 (5′9″).

The younger son (6′2″) of *J.G.* and his second wife is now 35. He married an English woman from Yorkshire, who is just under six feet tall (5′11″). They have three children, a daughter, who is 15 and is 5′6″; a son, aged 12 and 5′6″, and a four-year-old-girl. None of this F_2 generation is married.

The third wife of *J.G.* was 6′0″ in height. They had two children. The elder, a daughter (6′0″), now 28 years of age is unmarried. The younger, a son (6′2″), is now 22 years old; in January 1935, he married an English Canadian woman, who is 6′0″ in height.

In this family, conscious selection of tall mates and pride in their height is recognized by them. Great height has been maintained in three filial generations.

The **Be.** *Family*

Another case of selective mating and its effects on stature was observed by one of us in South Africa, the *Be.* family being noted for tallness, longevity and the large number of males in the family.

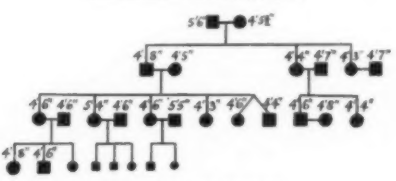
The couple, with whose descendants we are well acquainted, was a man 6′8″ in height and his wife who was 6′4″. They had a family of five: a son (6′6″), a son (6′7″), a son (6′3″), a daughter (6′0″), a son (6′0″). The third F_1 son (6′3″) married a woman who was 5′11″ in height. They had seven children, the third and sixth being daughters. The heights of this F_2 generation are: 6′4″, 6′2″, 5′10″, 6′0″, 5′11″, 5′11″ and 6′0″. The second

F_2 son (6'2"), married a woman 5'10". They have three sons and one daughter. The eldest son at 23 years of age was 6'2" in height; the second son at 21 was 6'0" tall; the third son at 19 was 5'11" in height and still growing, while the only daughter when 15 years old was 5'8". All were well-built, healthy and athletic persons. The youngest son (6'0") of the F_2 generation married a woman 5'10" in height. They have a family of four sons and one daughter, two sons and one daughter each being 5'10" and two sons each 5'8", while their ages range from 21 to 15. This family also is well-proportioned and strong and healthy.

While some members are proud of being unusually tall, others consider that their height is a disadvantage. However, in the successive generations a tendency is shown to regress towards average heights, and some of the younger men are known to have chosen wives of rather more ordinary heights, though the older ones preferred very tall women.

Inheritance of Shortness

Some cases of inheritance of shortness due to conscious or subconscious mate selection have also come under our observation and may be described.



THE B. FAMILY

Figure 21

Short Canadians of British stock. The founder, who was rather short, married a very short woman and his married children and grandchildren also chose short mates, resulting in perpetuation of shortness.

The *B.* family is of British stock, long resident in Canada, of whom members of the F_1, F_2 and F_3 generations are known to us. The founder of the family *R.J.B.*, came from Ayrshire, Scotland. He was 5'6" in height. He married an Inverness woman, 4'5½" in height, who is considered to have introduced "small size" into the family, as she came of a family of short people. They had three children born in Scotland, but the family migrated to Canada when the children were young.

The F_1 generation consists of a son (4'8"), who married a Scotch woman (4'5"); an elder daughter (4'4"), who married a Scot (4'7"); and a younger daughter (4'3"), who married a man 4'7" in height. The F_2 generation, who are known to us, are the children of the son, and of the elder daughter.

The family of the son consists of six children, all born in Canada. The eldest is a woman (4'6") now aged 42; she is married to a man who is also 4'6". The second, a woman, aged 40, is 5'4" and is married to a man who is 4'6". The third, a woman, aged 36, is 4'6" and is married to a man who is 5'5". The fourth, a woman, aged 28, is 4'3" in height and is unmarried. The fifth and sixth members are non-identical twins, now aged 22, namely, a woman who is 4'6" and a man who is 4'4". Both at present are unmarried.

The elder F_1 daughter has two children. The elder, a man (4'6"), now aged 32, has recently married a woman 4'8". The younger is a single woman (4'4") about 28 years old.

The F_3 generation consists of the families of the eldest, the second and the third F_2 women.

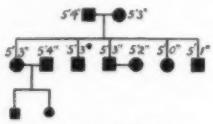
The family of the eldest F_2 woman is an unmarried daughter aged 22, who is 4'8" in height; an unmarried son aged 20 and 4'6" in height and a girl of 12.

The family of the second F_2 woman consists of two boys and a girl, all under 10 years of age, but small compared with other children of their age.

The third F_2 woman has two children: a boy 11 and a girl 7, both smaller than children of the same age who live near them.

The members of the F_1 and F_2 generations are of the opinion that most of them marry husbands or wives about their own size. Of the five *B.* women

in these two generations who married, four married men either taller or the same height as themselves, and one married a man ten inches shorter than herself. The wife of the man of the F_1 generation was a little shorter than he was, but one man of the F_2 generation married a woman two inches taller than he was. As a whole, members of the *B.* family do not seem to see anything unusual in their shortness. It is clear that some of them realize that marriages into the family have tended to keep the family short.



THE *R.* FAMILY
Figure 22

Short French Canadians, who are well built and sturdy. The founder married a short woman. Their five children were all short, none being as tall as their father, and two being shorter than their mother.

The *R.* family are French Canadians resident in Quebec Province. They are of sturdy farming stock and relatively well-to-do. The members of the family are all short, are glad that they are so, and are somewhat contemptuous of tall people. The eldest member of the family know to us, *E.R.*, is a man now 50 years old, who is 5'4" in height. He is the youngest of four brothers, two of whom are dead. The height of his surviving brother is 5'5". *E.R.* married a French Canadian woman, now 48 years old and 5'3" in height. Her family "like small people and have no use for great big folk." The family of *E.R.* consists of five children. The eldest is a daughter (5'3"), now aged 28. She is married to a man (5'4"), now 30 years old. They have two children, a boy aged 7, who is 2'10", and a small girl aged 4. The second member of the F_1 generation, a man (5'3"), aged 26, is unmarried. The third member, a man (5'3"), aged 22, recently married a woman who is 5'2". He considers it better to be short than tall, since short people do not need to spend so much money on materials for making clothing. The fourth member, a woman (5'0"), is 21. She is betrothed to a man who is 5'4", and she very candidly informed us of suitors she had rejected because they were too tall, and she emphatically preferred a man more her own height. The fifth member of the family is an unmarried man (5'1"), aged 20.

From conversations with the different members of this family, it is evident that the conscious selection of life-partners of short height has occurred and is occurring among them. This has undoubtedly resulted in the perpetuation of relatively short stature in the family.

The W. Family

Inheritance of shortness in four generations of a South African family is known to us. The family is, and always has been, of good social position and prosperous. The founders of the family, as known to us were a man (5'4") and his wife (4'8"). Their family consisted of four sons and three daughters, none of whom was more than 5'2" in height. The eldest of the F_1 generation, a son (5'2"), married a short woman. They had twins, a son and a daughter, who were both 4'0" tall when they died of diphtheria at the age of 17. The third son of the F_1 generation was 5'2". He married a woman 5'0" in height and they had six sons, all about 5'2" in height, this being described as "the family size." The second son of this F_2 branch (5'2") married a woman 5'3" and they have three sons and three daughters. The eldest of this F_3 generation is a woman (4'9"), married to a man 5'4". They had two very small children, boy and girl. The next F_3 members were twin sons who, when 25 years of age, were each 5'0" in height and unmarried. The fourth member, an unmarried woman, at 24 was 5'2". The fifth member, an unmarried son, was 5'1" when 22 years of age and, the sixth, a daughter, was 5'1" when 17 years old. When at school, the F_2 brothers were nicknamed

the "pigmies." However, they were strong and athletic.

The fourth member of the F_2 family of six brothers, who was 5′2″ in height, married a woman 5′5″, but there were no children of the marriage.

The fifth member of this family, who was also 5′2″ in height, married a woman about the same height as himself. They are stated to have had three young children, all under ten years of age when last heard of, but details were not available.

Some members of the *W.* family are quite conscious of selective mating as a factor in maintaining the short size of the family. As one member stated, "Being little men, our family have never married big women. It looks too silly. But I suppose we ought, so as to breed out our shortness." In this family, good environment and prosperous conditions have prevailed over four generations and, consequently, it may reasonably be concluded that no improvement of feeding or environment would have resulted in appreciable increase of height in the F_3 generation.

Discussion

In the foregoing, details have been presented of the perpetuation of tallness in several generations of two families in Canada and one in South Africa and of shortness in two Canadian families and one South African family. In connection with these families, the following points are of interest. Tallness or shortness has extended over several generations. There have been no cousin marriages. In some families, more than one nationality has entered into the pedigree. In these families the conditions of living have been satisfactory throughout, the environments have been conducive to active, open-air living and the standard of health has been satisfactory. The conditions have been such as to favor the development of good physique. The tall people and the short people alike have been well-proportioned; none showed pathological conditions. Mentally, all those known to us have been alert and vigorous, some distinctly able.

In the cases of tall families, there is some indication of slight decrease in stature in the younger generations, a slight regression towards more average height. In the short families there seems little indication of any increase in family stature at present.

In both tall and short families, there has been selection of husbands or wives of much the same height as themselves, such selections being definitely conscious in some cases and subconscious in others, judged from the voluntary, unsolicited statements of various members. There can be little doubt that such selection has been a considerable factor in determining the maintenance of tallness or of shortness in these cases. Since good environments, as already stated, have been enjoyed by these families, the effect of environment on stature can be largely ruled out. The heredity factor seems dominant and has been maintained and perhaps intensified by selection. It may be that, in times past, when isolation of small communities was commoner than it is now, human strains of tall or short stature may have originated by selection of mates of like stature.

Whether greater height or less than usual height is an advantage in a population is somewhat debatable, and many more cases would need to be investigated before any generalisation could be made. However, occupational disabilities might arise among either very tall or very short persons. Glandular defects are well-known to occur in connection with extreme tallness and such bar their carriers from certain occupations. The case of very short people also presents difficulties. Some occupations are entirely barred to them and certain types of work present considerable difficulty. That short people can do hard work and can have great powers of endurance was shown by the so-called "Bantam" battalions of English soldiers during the Great War. Actually, the families of little folk described in this paper were well-propor-

tioned and vigorous people to whom lack of inches had not been any great disadvantage. Nevertheless, there remains a feeling that such shortness imposes economic and social restrictions and that marriages with taller people would be an advantage. In the cases of both very tall and very short people, it would seem advisable that mate selection should be such as would result in the future generations being of more normal or average stature.

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A Bibliography of Intelligence Tests

THE July, 1935, number of the *Psychological Bulletin* is devoted to a review and summary of recent publications on tests of intelligence, educational psychology, and character and personality. The bibliography of 152 titles dealing with publications on intelligence tests made in 1934 contains references to the study of inheritance of mental ability and of lack of it, to the extent to which a high I. Q. remains constant during development. Tests initiated in 1922 by Hollingsworth show that among a group of children having very high test intelligence at an early age, there is no tendency to a regression toward average intelligence as the children grow older.

Considerable discussion is reported on the subject of racial differences in intelligence. No significant differences appear to have been uncovered by psychological research. Whether this is a reflection on the proponents of racial differences or on the inventors of intelligence tests does not appear from the discussion.

The character and personality tests do not seem to have reached a state of stabilization where the study of inheritance of differences in personality can be undertaken. The educational tests seem to be rather a hectic battle ground. The questions of what is being tested for, and what use the results can be put to in vocational guidance, seem to be matters that the experts in this field are by no means able to agree about.

To an outsider it looks as though the question of adequately controlled experimentation was at the bottom of many of the difficulties encountered in evaluating these tests. The most hopeful way of obtaining an objective answer to questions about the human psyche would seem to be by somehow utilizing identical twins to make possible controlled experiments in this field. In this connection the recent report in the *Journal* of Russian studies of eight hundred pairs of identical twins would appear to have very important implications.

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Physiology of Birth Control

The technical papers presented before the American Conference on Birth Control and National Recovery at Washington, January 15, 1934, have been brought together in a volume entitled *Biological and Medical Aspects of Contraception.* Copies of this are available to members of the medical profession interested in the subject and may be obtained by addressing the National Committee on Federal Legislation for Birth Control, 1343 H Street, N. W., Washington, D. C. Much of the material has rather general biological interest, as for instance the discussions of the ovulation cycle, and the immunity reaction induced by sperm injections. It is to be regretted that this material is published in a volume that the existing laws make available only the medical practitioners whose interests are more likely to be limited to the more strictly clinical aspects of the subject.

R. C.

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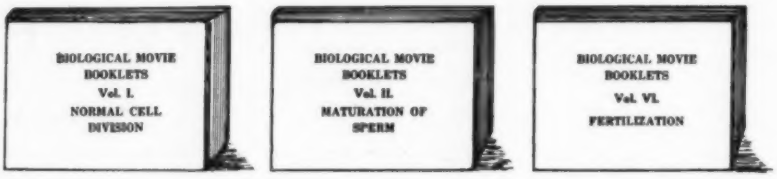

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